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GROUNDWATER QUALITY ASSESSMENT WITH GRAPHICAL METHODS AND GQI INDEX IN HARAZ ALLUVIAL FAN, NORTHERN IRAN

SUMMARY

Evaluation of ground water quality is important for assurance of safe and stable application of this source. However, quality conditions description is generally difficult with regarding to spatial variability of pollutants and a wide range of indicators (biological, physical and chemical substances) that can be measured. In this research, ground water quality of Haraz alluvial fan, located in the south part of Caspian Sea, has been investigated with Piper, Scholler, Wilcox and GQI methods. Piper diagram results showed ground water style and Calcium bicarbonate face at 90.3% groundwater samples, and Sodium bicarbonate at 9.7%. Scholler diagram shows acceptable quality of water and it has been determined by Wilcox method that 19.35% of the data are in class C2S1, 77.42% are in class C3S1 and 3.23% in class C3S2, indicating average water quality. Investigation of water samples with GQI method also showed that the study area in terms of the indicator is in the range of good.

Keywords: Groundwater quality, Piper method, Scholler method, Wilcox method, GQI, Haraz Alluvial fan

INTRODUCTION

Increasing population growth and rising living standards in many countries necessitate higher quality water resources for various uses as agriculture, industry and drinking (Rahmani, 2010). In this way, groundwater resources as valuable reserves and infrastructure developing countries have considered and tried to understand the capabilities of these resources and their usage can be found (Mohamahi et al, 2011).Groundwater is almost globally important for human consumption as well as for the support of habitat and for maintaining the quality of base flow into rivers. They are usually of excellent quality. Being naturally filtered in their passage through the ground, they are usually clear, colourless, and free from microbial contamination and require minimal treatment (Babiker et al, 2007). Water quality with respect to path length and abundance of soluble ingredient can be very different in various parts (Mahdavi, 2011).

A groundwater threat is now posed by an ever-increasing number of soluble chemicals from urban and industrial activities and from modern

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agricultural practices. Nevertheless, landslides, fires and other surface processes that increase or decrease infiltration or that expose or blanket rock and soil surfaces interacting with downward-moving surface water, may also affect the quality of shallow groundwater (Babiker et al, 2007). Aquifers face with different risks such as declining aquifer levels, reduced feeding due to lack of rainfall and normal and abnormal pollutants. So groundwater quality monitoring is extremely important (Mohamadi et al, 2011).

Measuring the chemical composition of groundwater is to determine its suitability as a source for human use and animal consumption, irrigation, industrial purposes and the others. Water quality refers to the physical, chemical, and biological characteristics that are required for water uses. Therefore, water quality monitoring is important because clean water is essential for human health and integrity of aquatic ecosystems (Hiyama, 2010). Also quality evaluation will be clear vision of groundwater quality trends and risk of contamination of water resources to specialists and managers (Nakhaei et al, 2009).

In evaluation of ground water, the goal is water quality investigation and planning for sustainable application of these sources.

There are several methods to determine water quality. The most common methods of assessing water quality for drinking, is Scholler diagram, that provides possibility of water study at a certain point of the area, but, the spatial variability of groundwater quality cannot be evaluated by this diagram, For this reason, Babiker et.al in 2007 has introduced Groundwater Quality Index (GQI), which is used to spatial evaluation of Groundwater quality (Rahmani et al, 2011).

In assessing of water quality for agriculture, Wilcox method is a common method that is used in different regions of the world.

Piper diagram indicates chemical characteristics of water in terms of relative concentrations of the major cations and anions. By description of its application, we can quickly determine type and frequency of components of the solution.

Groundwater chemistry patterns in the phreatic aquifer of the central Belgian coastal plain using Piper diagram were determined. Main processes determining general water quality are cations exchange, carbonate mineral dissolution and oxidation of organic matter (Vandenbohede and Lebbe, 2012). In Geochemical and statistical evaluation of groundwater in Imphal and Thoubal district of Manipur, India, Wilcox plot and USSL diagrams were used for delineating spatial and temporal variability in groundwater quality and understanding its suitability for human uses. The study reflected the overall suitability of groundwater for anthropogenic use (Devi Oinam et al, 2012). Hydro geochemistry of groundwater in parts of the Ayensu Basin of Ghana with using 25 water samples analysis with Piper diagram indicated that dominant composition of water was Na-Cl and Na-HCO3-Cl (Zakaria et al, 2012). In examining the origin and evolution of brine in Mighan Playa of Iran which used Piper and Stiff diagrams, that water inlet type was Na-(Ca) - (Mg) SO4-Cl-(CO3) and during Geochemical evolution and evaporation, mineral deposition of brine was Na-Cl-SO4 type (Abdi and Rahimpoor Bonab, 2010). Aquifers quality for drinking in Dargaz, Iran, was assessed by using GQI index and Scholler method. GQI index changed between 66 to 86 and indicated moderate to good groundwater quality for drinking. But with using Scholler method, water samples are placed in good to very unpleasant category (Sayyad et al, 2011). Hydro geochemical study of water in Chegart mine by using graphical and statistical method showed that using conventional graphical methods such as Piper and Stiff diagrams for classification water samples is efficient especially in the case of few data (Eslamzadeh and Morshedi, 2011). Groundwater quality determined with using GQI index in Nasuno basin, Japan showed good water quality. In this study, the GQI value was more than 90 (Babiker et al, 2007). For groundwater vulnerability assessment using GQI index in Nasuno, Japan, Hiyama (2010) concluded that water quality was good and GQI index was 83.

In the study area, due to the proximity to the Caspian Sea, close to the surface of the groundwater level, doing agricultural operations and the suitability of soil, groundwater quality degradation is more likely. Thus, ground water quality was evaluated using Piper, Wilcox, Scholler, and GQI methods. Evaluation of groundwater quality in combination with the above-mentioned methods were commonly accepted in the world for determining water quality for agriculture and drinking uses, giving more comprehensive information of groundwater quality in Haraz alluvial fan and provide condition for better management of this valuable resource and sustainable usage is possible.

MATERIAL AND METHODS

Study area. Haraz alluvial fan is limited to Caspian Sea from north and Alborz mountain range from south and surrounds Amol and Mahmaoud Abad cities. This region was located between $52^{\circ}\ 19'\ 5''$ E and $52^{\circ}\ 35'\ 9''$ E Longitudes and $36^{\circ}\ 24'\ 5''$N and $36^{\circ}\ 39'\ 40''$ N latitudes and Haraz River is the main river of this area. Studied area in terms of geology contains sandy coast-line (QT2C) and agricultural Los of covered areas (QC) (Figure 1).

Chemical analysis of water samples provides much information that must be analysed for given goals. These analyses are useful for many practical problems such as studying of Mixing of waters from different sources, ground water quality condition in an area, effect of different structures on water quality, investigation of origin of salinity. Water quality changes in the direction of its flowing, changes in water quality over time and impact of water extracting on quality. In this research, 31 wells that have EC, T.D.S, pH, Ca, Mg, Na, K, HCO3, Cl, CO3, and SO4 data in 2006 were used (Table 1).

Then, data were analysed in Excel. Excel is capable of just analysing of 23 wells data and draws the diagrams. Thus, in this project at the first stage, 20 wells data with the name of 1 were given to the software and in the next stage data of 11 remained wells with the name of 2 for data analysing and graph drawing entered in the software. These two names are visible on the top of the graphs. GQI method was performed in ARCGIS.

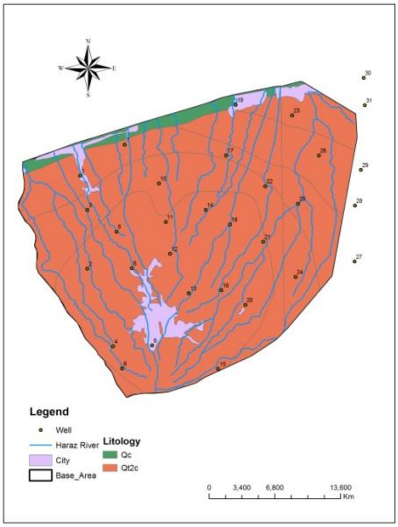

Figure 1. Study area with location of wells, city and regional geology

Hydrochemistry graphical methods for categorical data.

Piper diagram is made of combination of three different fields that implements anions and cations percentage in triangle fields and their combined condition in rhombus Square. Percentages are calculated in terms of Equivalent in millions of main ions.

Wilcox Method. Today, the most common method for water classification in terms of agriculture is Wilcox. In this classification, two factors considered (The electrical conductivity and Sodium adsorption ratio) and each of them are divided to four parts that totally results in the emergence of 16 water quality groups. In Wilcox diagram S is indicator of Sodium adsorption ratio and C is representative of electrical conductivity. The larger are the indices; the worse is condition of water quality.

Scholler Method. The most important quality criterion for classification of water in terms of drinking with the usage of Scholler diagram are the main water-soluble salts inclusive of anions and cations, total dry residue and total hardness of water resources. The total dissolved solids (TDS) are an effective parameter in the taste of drinking water. The water that has TDS lower than 500 mg, in terms of drinking standards, is considered as very good water. TDS between 500 and 1000 is favourable and TDS value from 1000 to 1500 is allowed for drinking but above 1500 mg is not suitable (Dindarlou et al, 2006). Scholler diagram is a graphical method for drinking water quality classification. In this diagram, studied waters are divided into 6 groups including good, acceptable, average, inappropriate, generally unpleasant and not-potable. This diagram is a traditional method in which parameters are separately evaluated, final quality is determined by the worst quality and its parameters are fixed.

Ground Water Quality Index (Gqi). In this section, the authors selected GQI that enabled change of water quality data to an understandable format. This index provides a method for summarizing of water quality condition that can be obviously notified to different researchers and also can help to understand whether total quality of ground water components are regarded as a potential threat for different application of water. In this section, we used GIS for the above mention method. For calculation of GQI like stated graphical methods, we used chemical analysis result of 31 samples. In GQI method, six chemical parameters (T.D.S, Ca, Mg, Na, Cl, and SO_4) that have high frequencies in ground water and are important for human health, are compared with WHO standards.

For this purpose, firstly we provided related parameter concentration raster map in ARCGIS with Kriging interpolation of point data and then for having one common scale with the use of the following formula, concentrations of each pixel (C) in raster maps have been created in the last step, making a connection with WHO standard of that parameter (C WHO).

$$C_{i\text{-}new}=C_i – C(WHO)_i/C_i+C(WHO)_i \qquad (1)$$

The results of these unifications are production of six new maps with value range from -1 and 1. Concentrations in these maps are graded between 1 and 10 until graded map of each parameter was obtained. In these maps, 1 is indicator of good quality of ground water and 10 is indicator of destruction of ground water quality. Indeed, in this unit conversion, -1 in the previous step map should be converted to 1, 0 to 5 and 1 to 10 in the graded map. For this purpose, we use the following Polynomial function for conversion of each pixel of the previous map (C) to new value (R) (Figure 8, 9, 10, 11, 12, 13) (Babiker et al, 2007).

$$R=0.5\times C^2+4.5\times C+5 \qquad (2)$$

For the creation of a map that is representative of all six chemical parameters and showing quantity condition of ground water quality compared with WHO standard, application of GQI index and related layers parameters were combined (Figure 14).

$$GQI = 100 – ((r_1\ w_{1\ +}\ r_2\ w_2+...+r_n w_n)\ /N) \qquad (3)$$

$$W = mean\ r + 2 \qquad (4)$$

Where r is the maps that obtained from previous stage and N is final numbers of parameters. For calculating GQI from various parameters, weight average is taken. Parameters with higher value (the difference with the standard) have higher weight and as a result their influence is more significant (Hiyama, 2010).

Table 1. The parameters used to assess water quality

Number	Well name	EC	T.D.S	pH	Ca	Mg	Na	K	HCO_3	CO_3	Cl	SO_4
1	Kharbrabmahale	1049.0	667.5	7.8	92.0	37.2	58.7	1.7	436.2	0.0	65.7	55.2
2	Hoseynabad	689.0	441.5	7.9	73.0	28.2	16.1	1.1	335.5	0.0	17.8	26.4
3	Khardon kola amol	820.5	525.0	7.8	82.0	34.2	25.3	1.5	390.4	0.0	23.1	43.2
4	Aghozbin	769.0	479.5	7.7	80.0	32.4	18.4	1.4	372.1	0.0	19.5	36.0
5	Kolodeh	1284.5	821.5	7.8	134.0	48.0	42.6	1.9	558.2	0.0	49.7	91.2
6	Kasemdeh	866.5	556.0	7.7	87.0	33.6	28.8	1.5	414.8	0.0	26.6	40.8
7	Yamchi	1485.0	943.0	7.8	103.0	46.2	126.5	2.0	488.0	0.0	177.5	64.8
8	Kola safa	1165.0	741.0	7.7	119.0	44.4	39.1	1.8	503.3	0.0	30.2	103.2
9	Police rah amol	733.5	463.5	7.8	76.0	30.6	18.4	1.2	335.5	0.0	19.5	48.0
10	Skandeh	986.0	629.0	7.6	93.0	42.0	33.4	1.7	451.4	0.0	32.0	57.6
11	Rodbar	884.5	561.5	7.8	97.0	30.6	29.9	1.6	387.4	0.0	30.2	64.8
12	No kola	630.5	400.0	7.7	61.0	26.4	19.6	1.2	280.6	0.0	24.9	33.6
13	Sharm kola	897.0	573.0	7.8	90.0	33.0	34.5	1.5	396.5	0.0	33.7	52.8
14	Balamirdeh	817.0	519.0	7.7	78.0	36.0	25.3	1.3	387.4	0.0	24.9	40.8
15	Pasha kola	870.0	556.0	7.9	94.0	31.2	27.6	1.5	402.6	0.0	33.7	40.8
16	Heshtelpaeen	916.5	587.5	7.6	98.0	31.8	32.2	1.6	408.7	0.0	33.7	50.4
17	Afrasara	746.0	472.0	7.6	82.0	29.4	17.3	1.3	341.6	0.0	19.5	48.0
18	Eshkar kola	1382.0	877.0	7.6	147.0	53.4	39.1	2.1	600.9	0.0	40.8	115.2
19	Sorkh rood	539.5	354.0	7.7	78.0	22.8	15.0	1.1	295.9	0.0	19.5	45.6
20	Darvishkhey amol	1010.5	643.5	7.6	96.0	40.2	41.4	1.7	375.2	0.0	74.6	74.4
21	Spi kola	1437.5	917.5	7.6	115.0	42.6	108.1	2.1	607.0	0.0	85.2	76.8
22	Marzango	624.0	395.0	7.7	61.0	26.4	18.4	1.0	265.4	0.0	23.1	45.6
23	Bonehkenar	951.5	609.0	7.6	101.0	28.8	42.6	1.6	424.0	0.0	44.4	48.0
24	Shariat kola	1232.0	785.5	7.6	115.0	42.6	63.3	1.8	524.6	0.0	79.9	52.8
25	Ghiyas kola	1408.5	892.0	7.7	151.0	48.0	49.5	2.0	564.3	0.0	53.3	136.8
26	Form	1352.0	857.0	7.5	119.0	39.6	93.2	1.8	558.2	0.0	90.5	74.4
27	Karon	1041.0	666.5	7.5	95.0	33.6	61.0	1.7	366.0	0.0	71.0	64.8
28	Talikran	1546.0	986.5	7.7	106.0	45.6	139.2	2.2	539.9	0.0	149.1	96.0
29	Roz kenar	2060.0	1297.0	7.6	122.0	51.0	227.7	2.5	607.0	0.0	289.3	96.0
30	aryakenar	806.5	512.5	7.7	78.0	31.2	31.1	1.3	363.0	0.0	33.7	40.8
31	Rodbast	1633.5	1040.0	7.6	142.0	59.4	90.9	2.3	671.0	0.0	122.5	72.0

RESULTS AND DISCUSSION

Piper diagram. Data analysis using Piper diagram From 31 wells indicated that 28 wells had calcic bicarbonate and 3 wells had sodic bicarbonate faces. The dominant anions were HCO3 > SO4 >Cl (Right triangle), and the dominant cations were Ca > Mg >Na+K (Left triangle) (Figure 2, 3, table 2). Abdi and Rahimpoor Bonab (2010), determined type of Iran's Mighan Playa by Piper diagram. Their results show Na-SO4-Cl type and affecting factors for final solution are: precipitation, evaporation and reaction of meteoric waters with rocks in the basin. Nakhaei et al (2009), determined type of groundwater quality and qualitative evolution by using Piper diagram, and concluded dominant type of Torbat Heydariye plain of Iran is was sodium chloride and in some areas was sodic sulphate and dominant hydro chemical type of plain is functions of lithology, dissolution strength, and flow pattern. Zakaria et al (2012) in their research used Piper diagrams to determine water quality; they stated that dominant type of water is in effect of soluble salts in soil layers and the decomposition of organic material.

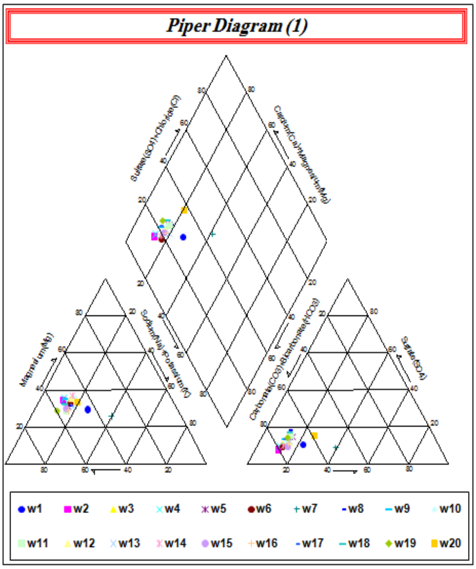

Figure 2. Piper Diagram (1)

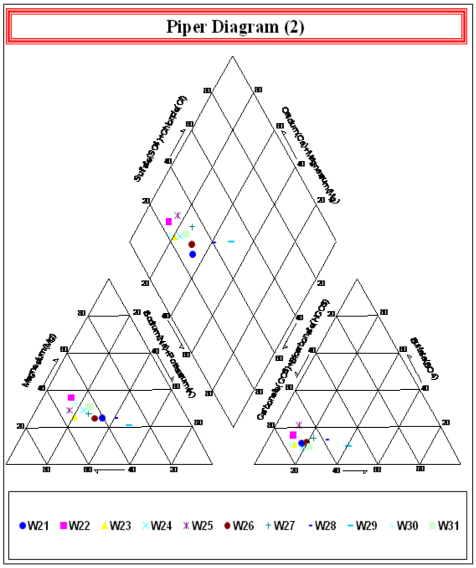

Figure 3. Piper Diagram (2)

Wilcox method. The results of Wilcox method indicated that ground water salinity hazard is in medium to high class and SAR is in low class excepted well number 29, that is in medium class (Figure 4, 5) and 19.35% of the data are in class C2S1, 77.42 % are in class C3S1 and 03.23 % in class C3S2 (Table 3, 4), and irrigation wells were salty and slightly salty and their applications for agricultural purpose are permitted.

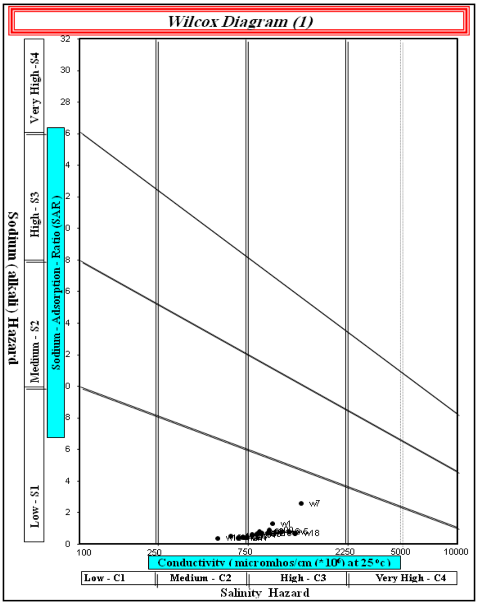

Figure 4. Wilcox Diagram (1)

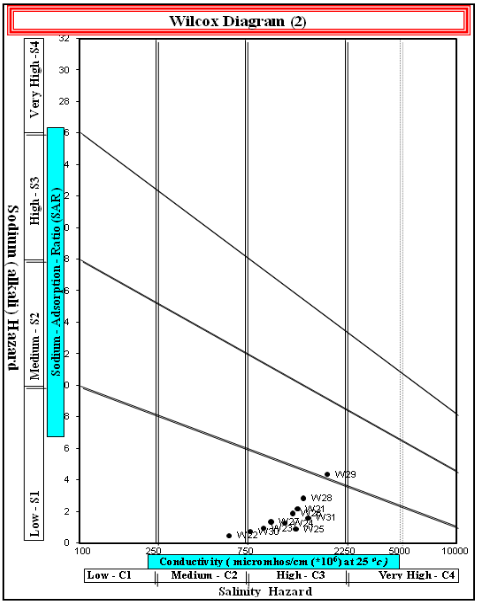

Figure 5. Wilcox Diagram (2)

Schoeller method. Schoeller diagram results showed that parameters change were similar in the different wells, and clearly indicates large amounts of bicarbonate in the water. Water quality in all wells except well number 29 are in good to acceptable class (Figure 6,7). According to various parameters (Table 1), well number 29 is located in average class (Figure 7).

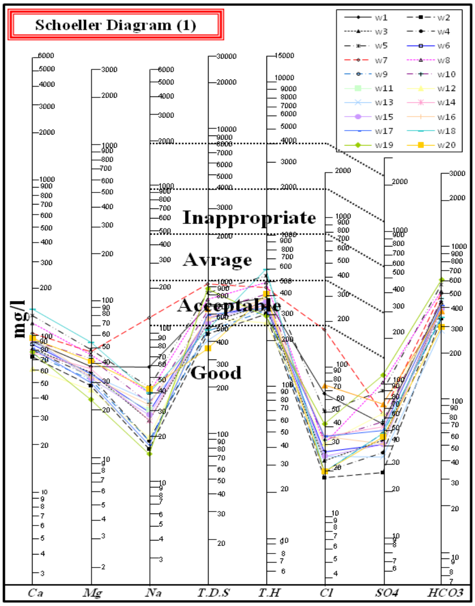

Figure 6. Schoeller Diagram (1)

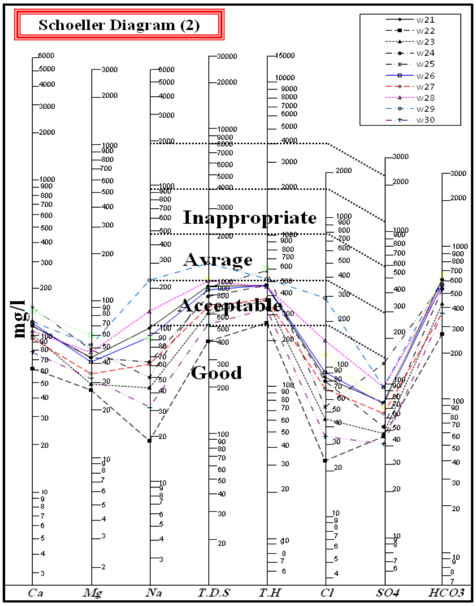

Figure 7. Schoeller Diagram (2)

Table 2. Types and facies in Piper diagram

Abbreviation	Well name	Anions concentration	Cations concentration	Type and facies
w1	Kharbrabmahale	HCO3 > Cl > SO4	Ca > Mg > Na+K	calcic bicarbonate
w2	Hoseynabad	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w3	Khardon kola amol	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w4	Aghozbin	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w5	Kolodeh	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w6	Kasemdeh	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w7	Yamchi	HCO3 > Cl > SO4	Na+K > Ca > Mg	sodic bicarbonate
w8	Kola safa	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w9	Police rah amol	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w10	Skandeh	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w11	Rodbar	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w12	No kola	HCO3 > Cl > SO4	Ca > Mg > Na+K	calcic bicarbonate
w13	Sharm kola	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w14	Balamirdeh	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w15	Pasha kola	HCO3 > Cl > SO4	Ca > Mg > Na+K	calcic bicarbonate
w16	Heshtelpaeen	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w17	Afrasara	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w18	Eshkar kola	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w19	Sorkh rood	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
w20	Darvishkhey amol	HCO3 > Cl > SO4	Ca > Mg > Na+K	calcic bicarbonate
W21	Spi kola	HCO3 > Cl > SO4	Ca > Na+K > Mg	calcic bicarbonate
W22	Marzango	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
W23	Bonehkenar	HCO3 > Cl > SO4	Ca > Mg > Na+K	calcic bicarbonate
W24	Shariat kola	HCO3 > Cl > SO4	Ca > Mg > Na+K	calcic bicarbonate
W25	Ghiyas kola	HCO3 > SO4 > Cl	Ca > Mg > Na+K	calcic bicarbonate
W26	Form	HCO3 > Cl > SO4	Ca > Na+K > Mg	calcic bicarbonate
W27	Karon	HCO3 > Cl > SO4	Ca > Mg > Na+K	calcic bicarbonate
W28	Talikran	HCO3 > Cl > SO4	Na+K > Ca > Mg	sodic bicarbonate
W29	Roz kenar	HCO3 > Cl > SO4	Na+K > Ca > Mg	sodic bicarbonate
W30	aryakenar	HCO3 > Cl > SO4	Ca > Mg > Na+K	calcic bicarbonate
W31	Rodbast	HCO3 > Cl > SO4	Ca > Mg > Na+K	calcic bicarbonate

Table 3. Wilcox classification class for agricultural purposes

Abbreviation	Well name	SAR	EC	Water class
w1	Kharbrabmahale	1.3	1049	C3-S1
w2	Hoseynabad	0.4	689	C2-S1
w3	Khardon kola amol	0.59	820.5	C3-S1
w4	Aghozbin	0.44	769	C3-S1
w5	Kolodeh	0.8	1284.5	C3-S1
w6	Kasemdeh	0.66	866.5	C3-S1
w7	Yamchi	2.59	1485	C3-S1
w8	Kola safa	0.77	1165	C3-S1
w9	Police rah amol	0.45	733.5	C2-S1
w10	Skandeh	0.72	986	C3-S1
w11	Rodbar	0.68	884.5	C3-S1
w12	No kola	0.52	630.5	C2-S1
w13	Sharm kola	0.79	897	C3-S1
w14	Balamirdeh	0.59	817	C3-S1
w15	Pasha kola	0.63	870	C3-S1
w16	Heshtelpaeen	0.72	916.5	C3-S1
w17	Afrasara	0.41	746	C2-S1
w18	Eshkar kola	0.7	1382	C3-S1
w19	Sorkh rood	0.38	539.5	C2-S1
w20	Darvishkhey amol	0.89	1010.5	C3-S1
W21	Spi kola	2.18	1437.5	C3-S1
W22	Marzango	0.49	624	C2-S1
W23	Bonehkenar	0.96	951.5	C3-S1
W24	Shariat kola	1.28	1232	C3-S1
W25	Ghiyas kola	0.89	1408.5	C3-S1
W26	Form	1.88	1352	C3-S1
W27	Karon	1.36	1041	C3-S1
W28	Talikran	2.84	1546	C3-S1
W29	Roz kenar	4.35	2060	C3-S2
W30	aryakenar	0.75	806.5	C3-S1
W31	Rodbast	1.61	1633.5	C3-S1

Table 4. Percentage of each Wilcox classification class for agricultural purposes

C4				C3				C2				C1			
S4	S3	S2	S1	S4	S3	S2	S1	S4	S3	S2	S1	S4	S3	S2	S1
0	0	0	0	0	0	3.23	77.42	0	0	0	19.35	0	0	0	0

Ground Water Quality Index (Gqi). GQI were as follows the maps r and weight w in the study:

GQI= 100 – ((2.9×4.9) + (3.95×5.95) + (3.2×5.2) + (1.81×3.81) + (2.53×4.53) + (4.305×6.305) / 6) = 83.36

Groundwater quality based on the index is in average rank (table 5).

Table 5. Water quality classification with Schoeller method

Classification of water quality for drinking	Na	Cl	SO_4	TH	TDS	GQI
Good	<115	<177.5	<144	<250	<500	>80
Acceptable	155 - 230	177.5 - 350	144 - 288	250 - 500	500 - 1000	
Average	230 - 460	350 – 710	288 - 576	500-1000	1000-2000	60 - 80
Inappropriate	460 - 920	710 - 1420	576 - 1152	1000-2000	2000-4000	<60
Completely inappropriate	920 - 1840	1420 - 2840	1152 - 2340	2000-4000	4000-8000	
Non-potable	>1840	>2840	>2340	>4000	>8000	

Hiyama (2010), Sayyad et al (2011) and Babiker et al (2007) used GQI method in their studies. The results of described unifications are production of six new maps with value range from -1 and 1 (Fig.8-14).

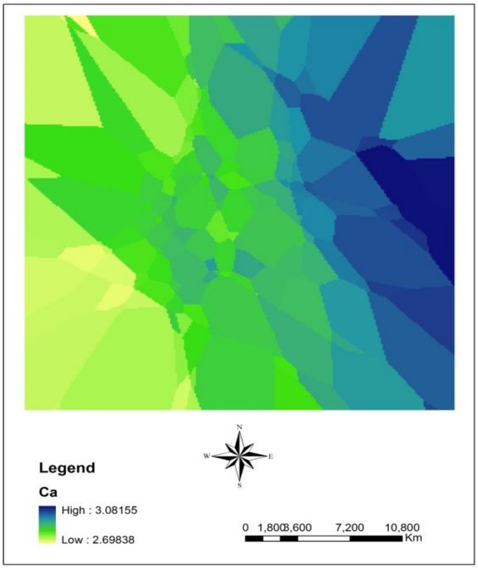

Figure 8. Ca r map

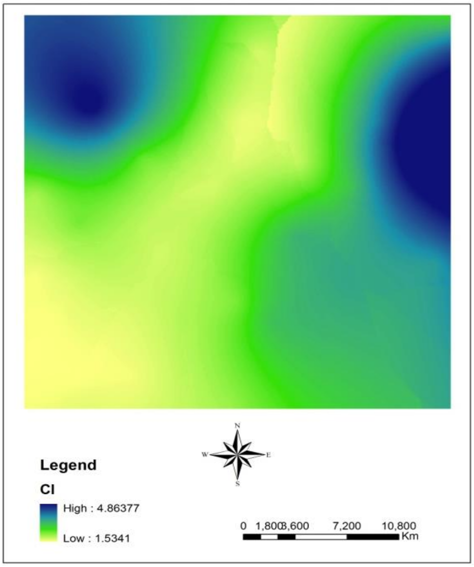

Figure 9. Cl r map

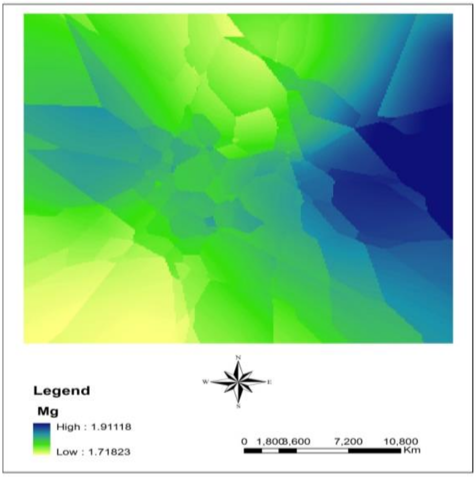

Figure 10. Mg r map

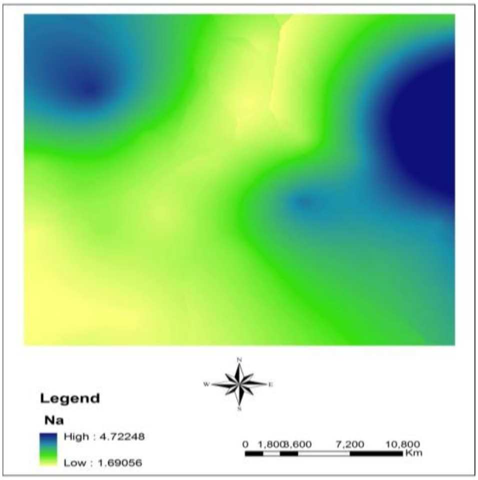

Figure 11. Na r map

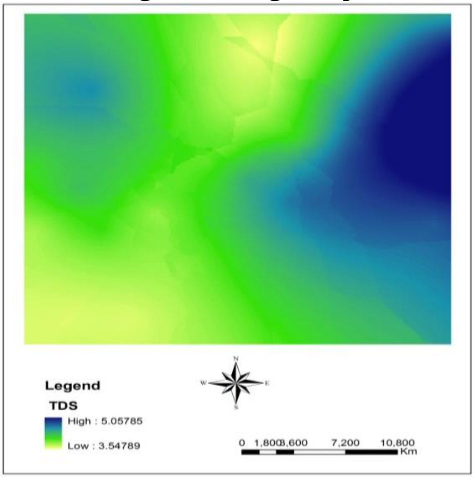

Figure 12. TDS r map

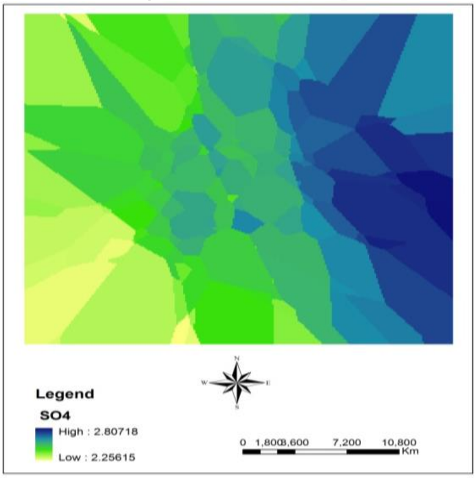

Figure 13. SO_4 r map

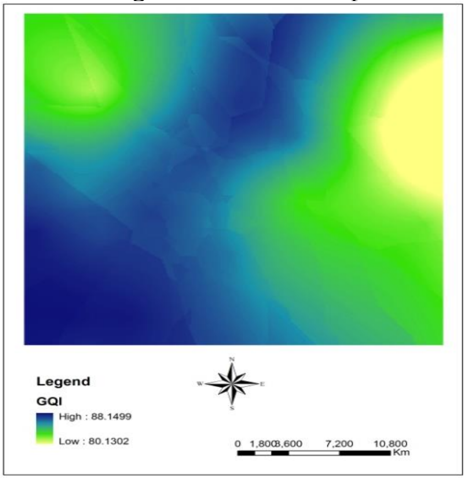

Figure 14. GQI map

With regard to presented results, we can state that almost all the methods represented acceptable ground water quality of studied area for drinking and agriculture. It can be due to abundant rainfall, low evaporation, and the region being as alluvial fan which causes water transfer from upstream the Alborz Mountains to downstream through Haraz river.

CONCLUSIONS

In this study, groundwater quality was assessed in Haraz alluvial fan with different methods. Results of Piper diagram represent type and faces of calcium bicarbonate in 28 wells and sodium bicarbonate in 3 wells.

Studying by Wilcox diagram suggested that 19.35% of the data are in class C2S1, 77.42% in class C3S1 and 3.23% in class C3S2. C2S1was indicator of water with good quality and C3S1, C3S2 were indicator of water with moderate quality and application of this water was suggested in irrigation of coarse lands with good drainage.

Scholler diagram showed acceptable water quality in most wells that could be used as drinking water. Water quality with GQI values between 80 and 88 is good. The number and type of parameters in this method is completely optional and this enables the researcher to suggest qualitative changes in accordance with the needs and problems of each region.

With regard to relatively good quality of this area, appropriate application of this vital resource is suggested.

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REFERENCES

Abdi, L. & Rahimpoor Bonab, H. 2010: HydrochemistryOrigin and brine evolution of Mighan Playa of Arak (Iran). Stratigraphy and sedimentology studies., Years Twenty-six, Serial 38, Number One.

Babiker, S. Mohamed, MAA. & Hiyama, T. 2007: Assessing groundwater quality using GIS. Water resource Manage. Springer science + Business Media B.V.21:699-715.

Devi Oinam, J. Ramanathan, A L. & Singh, G. 2012: Geochemical and statistical evaluation of groundwater in Imphal and Thoubal district of Manipur, India. Journal of Asian Earth Sciences., 48: 136–149.

Dindarlo, K. Alipoor, V. & Farshidfar, Gh R. 2006: Chemical quality of drinking water in Bandar Abas. Medical Sciences Journal of Hormozgan., Tenth year, (1) 57-65.

Eslamzaded, M. & Morshedi, A. 2011: Study of hydrochemistrysamples of water in Choghart mine using graphical and statistical. Journal of Land and Resources of Lahijan Branch.,Year 4, Number 2, Summer.

Hiyama, T. 2010: Evaluation of groundwater vulnerability (and sustainability). 20th UNESCOIHP training course DOI 10. 1007/S11269-006-9059-6.

Mahdavi, M. 2011: Applied Hydrology., in: Tehran University 9th ed. Tehran, Iran.

Mohamadi, M. Mohamadi Ghale Ney, M. & Ebrahimi, K. 201: Temporal and spatial variation of groundwater quality in Qazvin. Journal of Iran Water Researc., Years five, (8) 41-52.

Nakhaei, M. Vadiati, M. & Saberi Nasr, A. 2009: Hydro geochemistry Evolution of Torbate Heydariye plain. Fifteenth Meeting of Geological Society of Iran.

Rahmani, A. 2010: Study of ground water quality changes trend(case study: Qaemshahr – Joybar, Mazandaranprovince). MS Thesis, Natural Resources Faculty of Sari., 69-93.

Rahmani, Gh R. Chitsazan, M. Zaresefat, & M. Kalantari, N. 2011: Evaluation of ground water quality for drinking with GQI in Ize – Piyon plain. Fourth International Conference on Water Resources Management of Iran.

Sayad, H. Mohamadzaheh, H. Velayati, S. 2011: Assessment of water quality in Dargaz aquifer for drinking with using Scholler diagram and GQI index. Proceedings of the Thirtieth Meeting of Geological Sciences., Iran.

Vandenbohede, A. & Lebbe, L. 2012: Groundwater chemistry patterns in the phreatic aquifer of the central Belgian coastal plain. Applied Geochemistry., 27: 22–36.

Zakaria, N. Akiti, TT. Osae, Sh. Dickson, A. Ganyaglo, SY. Hanson, JEK. Ayanu, G. 2012: Hydro geochemistry of groundwater in parts of the Ayensu Basin of Ghana. Proceedings of the International Academy of Ecology and Environmental Sciences., 2(2):128-135.

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OCJENA KVALITETA PODZEMNIH VODA GRAFIČKOM METODOM I GQI INDEKS U ALUVILIJALNOJ RAVNI HARAZA, SJEVERNI IRAN

SAŽETAK

Evaluacija kvaliteta podzemnih voda je značajna radi potvrde bezbjedne i stabilne primjene ovog izvora. Međutim, opis uslova kvaliteta je generalno težak zadatak zbog prostorne raznolikosti zagađivača i velikog opusa indikatora (bioloških, fizičkih i hemijskih substanci) koji se mogu mjeriti. U ovom radu je vršeno ispitivanje podzemnih voda u aluvijalnoj lepezi Haraza, koja se nalazi u južnom dijelu Kaspijskog mora, pomoću Piper, Scholler, Wilcox i GQI metoda. Rezultati Piper dijagrama pokazuju stil podzemnih voda i postojanje kalcijum bikarbonata kod 90,3% uzoraka podzemnih voda, te natrijum bikarbonata kod 9,7%. Scholler dijagram pokazuje prihvatljiv kvalitet vode i Wilcox metodom je utvrđeno da 19,35% uzoraka pripada klasi C2S1, 77,42% pripada klasi C3S1 i 3,23% klasi C3S2, što ukazuje na prosječan kvalitet vode. Ispitivanje uzoraka vode GQI metodom je pokazalo da je posmatrano područje po pitanju indikatora u rangu dobrog.

Ključne riječi: kvalitet podzemnih voda, Piper metod, Scholler metod, Wilcox metod, GQI, aluvijalna ravan, Haraz