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Evaluation of Faryab spring hydrochemistry in Hormozgan Province, Southern Iran

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ABSTRACT: With a mean precipitation rate, much lower than that of the world, Iran is among the countries that face severe water challenges. The present study has dealt with the evaluation of hydrochemistry of Faryab spring water in Hormozgan Province, Iran. Four different composite water samples have been analyzed to detect major anions, cations, total dissolved solids, electrical conductivity, pH, and sodium absorption ratio. The dominant water type was detected as sodium-chloride, with remarkable high concentration of sodium and chloride ions that makes it unfit for drinking purposes. Regarding irrigation use, high values of electrical conductivity (29989 to 31983 µS/cm) and sodium absorption ratio (SAR) (58.1 to 61) indicate a very high risk level for salinity and sodium alkali hazards, respectively. Abundance of secondary minerals such as halite and gypsum is considered to be the main reason for remarkably-high TDS values. Intensity of salt domes within the area would also facilitate solution/dissolution process of Na+ and Cl- into water column.

Keywords: Faryab spring, geology, hydrochemistry, saline water.

INTRODUCTION

A secure water supply for different purposes (drinking, industry, irrigation, recreation, ecosystem services, etc.) has been appeared as a major challenge for lots of countries all around the world (Tsakiris et al., 2009; Rubiano-Labrador et al., 2014; Bakalowicz, 2015; McIntosh et al., 2011; Arfib & Charlier, 2016; Xiu-wei et al., 2016; Burg et al., 2016; Gue et al., 2015). For a country like Iran in the Middle East, in which the mean precipitation rate is much lower than that of the world, water supply may be more significant (Baghvand et al., 2010; Nasrabadi et al., 2015; Nasrabadi et al., 2009). It should be noted that within Iran, there are some provinces with mean precipitation values much lower than that of the country. Hormozgan Province covers most arid lands of Iran. Accordingly, when paying attention to different (or even non-conventional) water resources, one should have special priorities.

Hormozgan province is located in southern Iran between 25° 23', 28 57' N and 52° 41', 59° 15' E. This region has an arid/semiarid climate, with a surface area over 68,400 km^2. It lies on the north coastline of Persian Gulf, strait of Hormoz, and a part of Oman Sea. Hormozgan province is situated in a dominantly warm and dry zone of Iran with its temperature sometimes exceeding 49°C in the summer (Bakhtiari et al., 2013).

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The study area is recognized with predominant sedimentary and basic igneous parent rocks. Soil types are classified as Regosols, Leptisols, Arenosols, Cambisols, Solonchaks, Gleysols, Gypsisols, Calcisols, and Luvisols. And primary minerals consist of quartz, feldspar, mica, apatite, amphiboles, and secondary minerals such as evaporitic minerals (halite, gypsum, calcite, and dolomite) and phylosilicate ones (Illite, sepiolite, and 14 A-phyllosilicates), which have been identified in the studied soils (Abbaslou, 2012).

This province can be divided geologically into three distincts; Zagros, Makran, and Central Iran zones. The study area lies within Zagros zone. Both high Zagros and Zagros fold belt is called "Bandar Abbass Hinter land". These two sub-zones have structural dissimilarities, though they share common stratigraphic characters. In these two sub-zones, the following lithostratigraphic units have been recognized: Hormoz series in form of various salt diapers are exposed in central parts of the Province, though Paleozoic rocks have been mainly observed in the northern areas. Paleozoic sequences are not complete in these outcrops. There are non-depositional lacunes between graptolite-bearing shale (Silurian of Sar Chahan) and white quartzitic sandstone of Devonian (Zakin formation). A sedimentary lacune also exists between Upper Devonian and detritic sediments at the base of carbonatic Dalan formation (Permian).

Carbonatic sequences have been accumulated in the continental shelf of Neotethys Ocean. Cretaceous is specifically exposed in the axial part of many anticlines.

The lower parts of this carbonatic platform are Eocene and Oligomiocene (Asmari and Jahrom Formations) which constitute the axial part of very high anticlines of this province. Miocene rocks are detritic synorogenic sediments, deposited in marine environments, regressive to the south. These sequences are called Fars Group, which starts with gypsum accumulation (Gachsaran Formation or Razak Formation which is detritic equivalent of Gachsaran Formation), followed by marine marls of Mishan Formation, and finishes with red clastic sediments of Aghajari Formation. The youngest rock of this group is conglomerates of Bakhtyiari Formation, accumulated in lowest parts of anticlines or in the axial part of the synclines. Geological data of the study area have been provided by *national geoscience database of Iran* and more detailed data may be found there.

A variety of salt domes, namely Anguran, Siahou, Ahmadi, Larak, Qeshm, and Hormoz are observed as the main geomorphologic units of the study area (Asadpour, 2015).

Faryab Spring is located in the vicinity of Faryab Sanguiyeh village in Bastak county, in the western parts of Hormozgan Province (Fig. 1).

MATERIALS AND METHODS

The sampling procedure took place in summer 2015. Major cations (Na^+, K^+, Ca^{2+}, and Mg^{2+}) and anions (CO_3^{2-}, HCO_3^-, SO_4^{2-}, and Cl^-) as well as pH, EC (Electrical Conductivity), and TDS (Total Dissolved Solids) were measured for further analysis of Faryab Spring's water samples. EC and pH of water samples were measured in-situ by a digital pH/EC meter. The gravimetrical method was used at 105–110°C to determine TDS (Kazi et al., 2009). Filtered samples (through polycarbonate filters with 0.45 mm pore size) were divided into two groups. To measure the concentration of major anions, HACH DR/2000 (method number 8051), argentometric course (method number 2330), and titration (method number 4500) were employed for sulfate, chloride, and bicarbonate/carbonate respectively. Two milliliters of concentrated HNO3 was added to the samples, prepared for cations analysis. Except for Mg^{2+}, which was determined by flame atomic absorption spectrometer, the concentration of other cations (Ca^{2+}, Na^+, and K^+) were determined by flame photometry. For geochemical and statistical analysis the software programs, used during data processing, included Aqqa 2005, Excel2013, and SPSS11.

RESULTS

Figure 2 demonstrates the average annual flow of Faryab spring in recent years. The flow rate varies between around 100 and 180 L/s with an overall increasing trend.

Fig. 1. Location of Faryab spring in Southern Iran

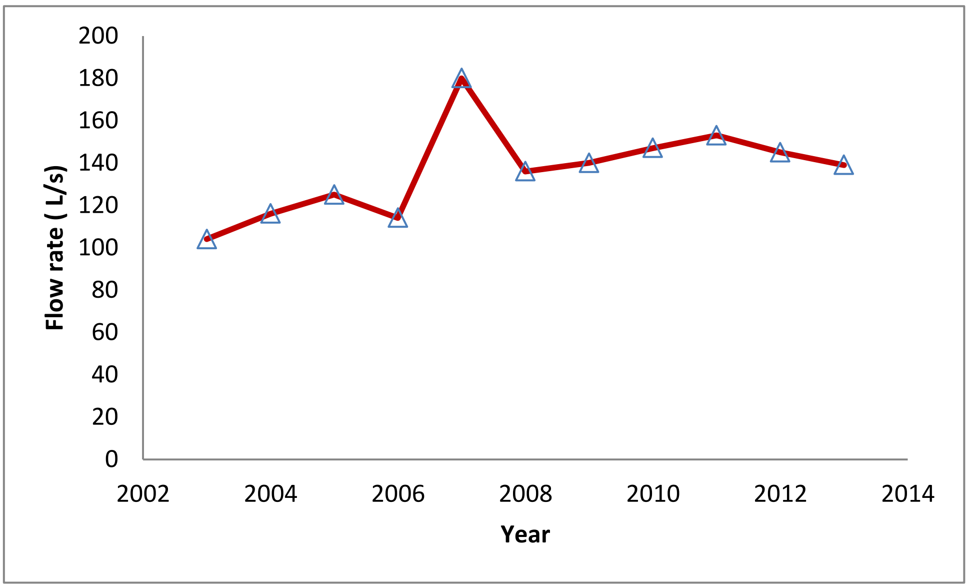

Fig. 2. Average annual flow rate of Faryab spring in recent years

Table 1 shows the hydrochemical characteristics of four different water samples, collected from the spring in 2015. Major anions and cations as well as pH, EC, TDS, and SAR (sodium absorption ratio) are demonstrated by the table. To cross-check the accuracy of the measurements, the sum of cations and anions have also been compared. Differences are within the acceptable range of ±5%.

Graphical methods were used to determine the dominant water type of different samples. Accordingly, Piper diagram (Fig. 3) and Durov diagram (Fig. 4) have been plotted. Generally, a significant similarity is observed among the behavior of different samples. Such integrity may be attributed to a geo-pogenic source of mentioned ions.

As it is seen in Figures. 3 and 4, the dominant water type is sodium-chloride. Sulfate content of water samples may be estimated around 10% while the presence of bicarbonate may be regarded as negligible. In case of cations, both calcium and magnesium may cover around 15% of the total concentration.

Schoeller diagram has been used to assess the water suitability for drinking purposes. Figure 5 shows the classification of different water samples within the diagram. While the critical parameters (Cl- and Na+) are located in the unacceptable range (more than 80 meq/l) all water samples are not at all suitable for drinking.

Table 1. Hydrochemical characteristics of water samples from Faryab spring

Sample	Anions (meq/l)				Cations (meq/l)				pH	EC (µS/cm)	TDS mg/l	SAR	∑ Anions	∑ Cations
	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}						
S1	314.6	41.31	3.722	ND	332.1	0.415	46.99	15.52	6.8	30094	22813	59.4	369.6	385.0
S2	312.1	38.02	3.163	ND	329.3	0.393	44.23	14.11	6.9	29989	22450	61	363.3	378.0
S3	331.5	47.20	3.944	ND	343.7	0.452	50.11	15.97	7.1	31983	24213	59.8	392.6	400.2
S4	317.9	40.44	3.551	ND	335.5	0.421	52.76	13.87	6.9	31547	23046	58.1	371.9	392.6

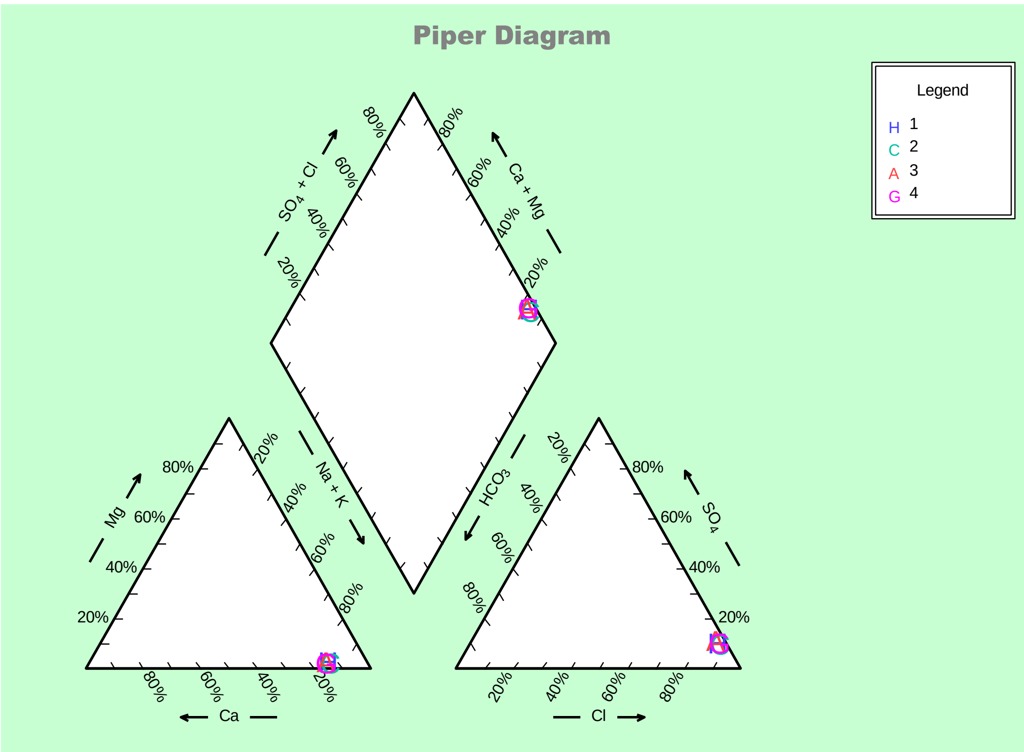

Fig. 3. Piper diagram of Faryab Spring water samples

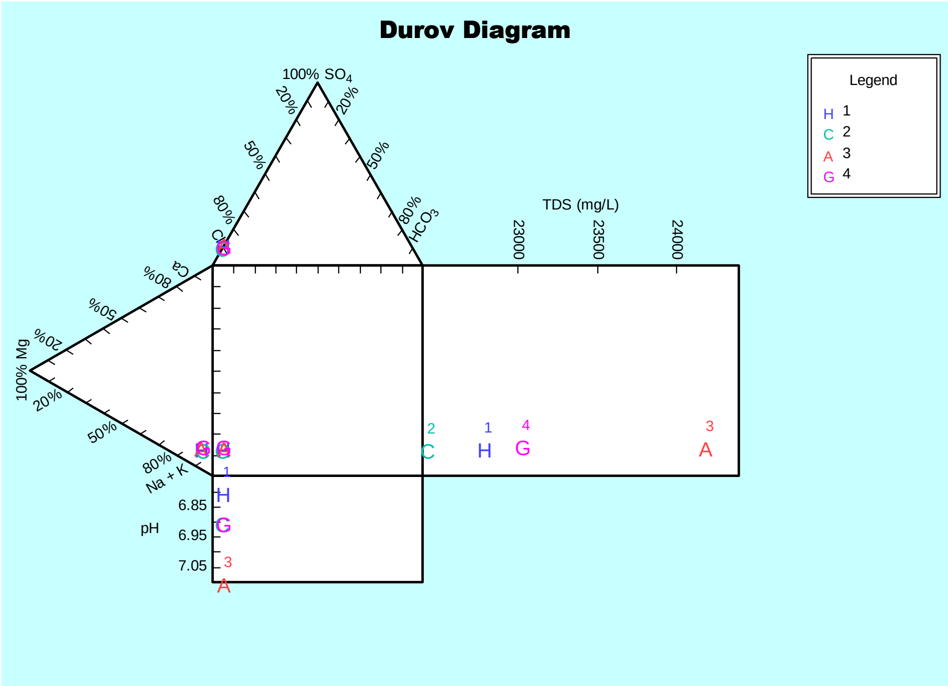

Fig. 4. Durov diagram of Faryab Spring water samples

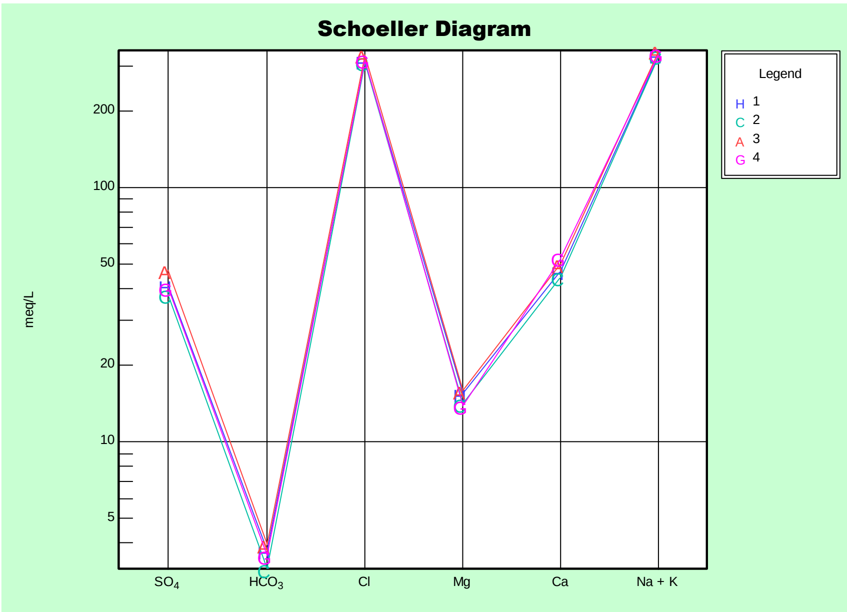

Fig. 5. Schoeller diagram of Faryab spring water samples

CONCLUSIONS

Hydrocemical characteristics of Faryab spring in western Hormozgan Province of Iran have been evaluated in this study, with the dominant water type detected as Sodium-Chloride according to piper diagram. Due to remarkable concentration of the above-mentioned salt, suitability for drinking purposes was extremely low. On the other hand, high values of electrical conductivity (29989 to 31983 µS/cm) and sodium absorption ratio (SAR) (58.1 to 61) indicate very high risk level, with regards to salinity and sodium alkali hazard, respectively. According to Wilcox classification scheme, all four water samples lie in C4S4 class, which are interpreted as unsuitable for conventional irrigation purposes. During recent years drip-irrigation has proven to be an applicable way to reclaim saline soils and is considered as a promising irrigation system to use saline/brackish water (Liu et al., 2012; Sun et al., 2013; Chen et al., 2015; Li et al., 2015; Li et al., 2017; Zeng et al., 2014; Yu et al., 2013). Geological texture of the study area, especially the dominance of secondary minerals including evaporitic ones (halite and gypsum), may be considered as the main reason for extremely high TDS values. Intensity of salt domes within the area would also facilitate solution/dissolution process of Na+ and Cl- into the water column (Asadpour, 2015).

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