Investigation of Hydrogeochemical Characteristics and Groundwater Quality of Hoz–e–Soltan Lake, Qom, Iran

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Abstract

In this research, the groundwater quality of Hoz–e–Soltan Lake and its catchment was studied for drinking, domestic and irrigation uses according to different parameters. This Lake with 195 km^2 catchment area is located 85 km of southwest of Tehran–Qom highway. In order to investigate groundwater quality characteristics in the study area, 34 data from water of well belong to 2008 selected to processing and interpretation. The data was edited and processed to determine groundwater quality parameters such as Magnesium Absorption Ratio (MAR), Sodium Solution Percent (SSP), Residual Sodium Bicarbonate (RSBC), Permeability Index (PI), Kelly Ratio (KR) and Sodium Absorption Ratio (SAR), Electric Conductivity (EC), Na^+, K^+, Mg^{2+}, Ca^{2+}, SO_4^{2-}, Cl^-, HCO_3^-. Based on Piper diagram and cations and anions abundance order, the groundwater type of the study area is currently classified as $Na^+–Cl^-–SO_4^{2-}$. On the basis of Schoeller diagram, amounts of Na^+, Cl^-, SO_4^{2-}, Total Hardness (TH) and Total Dissolved Solid (TDS) are higher than permissible limit and therefore, the water is unsuitable for drinking and domestic uses. The average pH values of the groundwater equal to 8, indicating alkaline nature of groundwater. Total hardness average of samples equal to 806.8, shows that the Hoz–e–Soltan groundwater was not suitable for drinking, domestic and irrigation uses. Sodium Content (Na %) average equal to 67.1, groundwater resources of the study area was belongs to the suspicious class. As a result, high salinity, SAR, TH, TDS, EC and Na% in most water samples have restricted the water quality for drinking, domestic and irrigation uses.

Keywords: Groundwater quality, Major ions, WHO standards, Semi–arid climate, Iran.

1–Introduction

Groundwater is the only reliable water resource for human consumption, as well as for agriculture and industrial uses in arid to semi–arid country like Iran. Rapid depletion of groundwater, continued population growth and industrialization that result in degradation of water quality, increase of pumping costs, emissions and pollution of groundwater resources, are the most threats for the quality of many aquifers in Iran. To evaluate the suitability of groundwater for different purposes, understanding the chemical composition of groundwater is necessary. Furthermore, it is possible to understand the change in quality due to rock–water interaction (weathering) or any type of anthropogenic influence (Todd, 1980; Kelly, 1940). Such improved knowledge can contribute to effective management and utilization of this vital resource. In this view, monitoring the quality of groundwater (chemical, physical, and biological constituents) is as important as assessing it's quantity. The main goal of the study was to determine the hydrogeochemistry of the groundwater and to classify the water in order to evaluate its suitability for drinking, domestic and irrigation uses.

2– Study Area

Hoz–e–Soltan Lake is an ephemeral saline Lake and according to the Sonnenfeld classification scheme (1991), is regarded as an intra–continental basin. Hoz–e–Soltan Lake has a 195 km^2 catchment area, 25–50 cm depth and is located 85 km of southwest of Tehran, in Central Part of Iran (Fig. 1). It is situated between 43°56' and 35°31' north and 50°53' and 51°20' east at western–north of Hoz–e–Masileh (Fayazi, 1991). The maximum superficial relief is about 1940 meters above mean sea level to the north and 1150 meters to the south. On the basis of Aqanabati's classification (2006), the study area is located in Central Iran geological. It is surrounded by Ali–Abad and Kushk–e–Nosrat Mountains in north and northeast, Manzarieh and Chahar Mountains in west, and Mohammad–Abad and Badamcheh Mountains in south and southeast). Orogenic movements and volcanic eruptions in late Cretaceous in early Eocene resulted in Eocene volcanic formation in north and central part of Iran, particularly around Hoz–e–Soltan Lake. Faulting resulting from volcanic activities caused the formation of a graben which was later filled with salt Lake. Up–stream outcrops of Hoz–e–Soltan Lake which include northern, north–eastern and western Mountains affect sediment type and Lake hydrogeochemistry. These up–stream outcrops are mainly composed of Eocene volcanic rocks (interlayering tuffs, andesite with sedimentary rocks). Oligo–Miocene sedimentary rocks (mainly composed of reefal limestone, glauconitic limestone with clastic basal conglomerate) distributed on southeast of the Lake (Motamed and Pourmotamed, 1979).

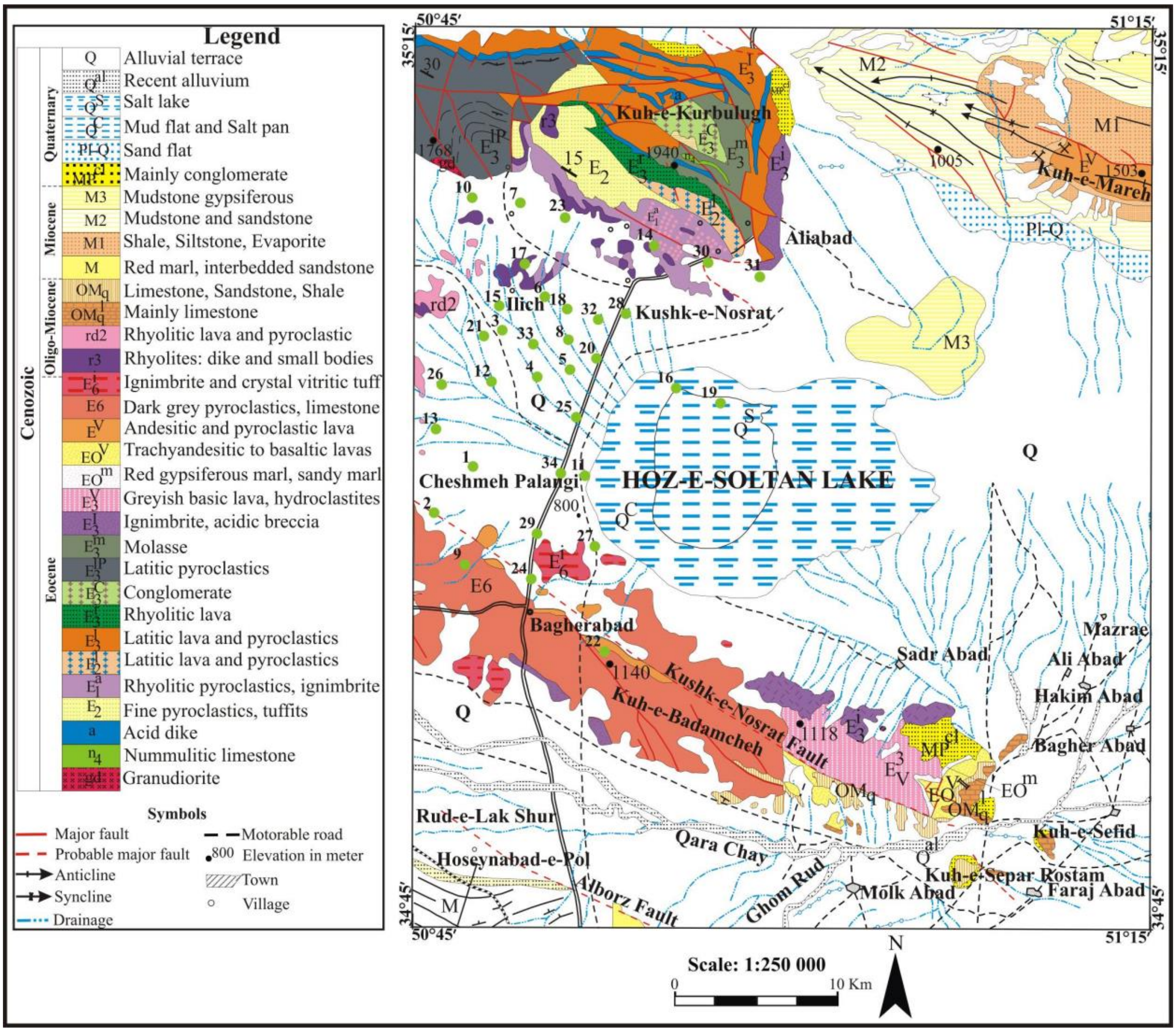

Figure 1) Geological map of Hoz-e-Soltan Lake and groundwater sampling locations

Table 1) Main cations and anions amounts and hydrogeochemical parameters of study area wells.

ID	X	Y	TH	K^+	Na^+	Mg^{2+}	Ca^+	SO_4^-	Cl^-	HCO_3^-	TDS	EC
W1	479292	3873014	180	0.1	11.7	1.8	1.8	4.0	7.6	3.9	943.4	1576
W2	478039	3871220	296.5	0.1	13.3	3.1	2.83	5.9	9.5	4.1	1174	1882
W3	483093	3883182	230	0.0	9.5	2.2	2.4	3.9	4.8	4.1	821	1411
W4	484775	3878869	315	0.0	9.8	2.8	3.5	6.7	6.5	3.5	991	1510
W5	486700	3879796	570	0.1	9.5	2.9	8.5	12.2	3.8	3.5	1288	2075
W6	486668	3882293	430	0.1	13.6	2.1	6.5	16.2	3.1	2.9	480	1965
W7	483717	3889915	300	0.0	8.3	2.0	4	5.5	6	1.5	793	1325
W8	487006	3880562	250	0.0	8.0	1.5	3.5	6.1	5.05	1.5	806	1254
W9	480530	3866940	185	0.0	10.8	0.6	3.1	4.7	4.4	4.15	821	1336
W10	481449	3890837	170	0.0	10.1	1.2	2.2	4.3	4.5	4.55	846	1250
W11	487643	3873078	1515	0.1	65.2	6.2	24.1	36.7	55.1	2.7	5911	9300
W12	486668	3882293	1565	0.2	65.5	10.1	21.2	42.5	53.5	2.1	6118	8770
W13	477865	3877295	1285	0.1	43.5	6.5	19.2	21.9	45.2	2.75	4242	6940
W14	492022	3887802	1150	0.1	89.5	8.5	14.5	63.8	45.2	3.8	7321	10860
W15	483093	3883182	270	0.0	8.3	1.5	3.9	6.4	5.5	1.5	799	1327
W16	494775	3878869	225	0.0	8.1	1.0	3.5	6.2	5.01	1.5	806	1252
W17	483631	3885488	1495	0.1	55.6	6.8	23.1	45.8	36.8	2.2	5457	8560
W18	486668	3882293	1420	0.1	52.2	6.4	22	31.8	45.2	2.1	4957	8000
W19	496838	3877490	1450	0.1	98.0	9.5	19.5	40.8	84.8	1.3	7820	12140
W20	488663	3879854	1335	0.1	93.8	7.5	19.2	43.5	75.2	2.8	7538	11760
W21	483093	3883182	1635	0.5	116.7	9.5	23.2	69.3	78.5	1.4	9517	14280
W22	488510	3863069	1485	0.5	110.2	9.5	20.2	70.5	68.6	1.5	9017	12900
W23	486299	3889485	1225	0.1	63.0	7.3	17.2	47.1	38.1	2	5617	8480
W24	484384	3866860	1015	0.1	60.9	5.2	15.1	41.2	35.5	1.5	5102	7300
W25	486838	3877490	420	0.1	11.3	4.6	3.8	6.4	9.7	2.6	1145	1814
W26	479050	3878869	210	0.1	11.1	1.5	2.7	5.3	6.8	3.7	963	1650
W27	487996	3870206	1980	0.3	104.7	22.0	17.6	45.1	96.2	2.5	8749	13840
W28	490769	3882754	1350	0.3	73.5	14.8	12.2	28.4	68.1	2.8	6035	8900
W29	485174	3870225	440	0.1	14.7	3.6	5.2	9.5	12.2	3	1496	2405
W30	495267	3886727	310	0.1	15.6	1.8	4.4	9.0	10.8	2.5	1389	2240
W31	497703	3886845	250	0.1	11.3	1.0	4	5.0	8.3	3.7	1029	1642
W32	489050	3882293	330	0.1	7.4	2.1	4.5	6.1	5.5	2.1	860	1335
W33	484415	3881667	1160	0.1	26.5	5.8	17.45	26.2	20	1.8	3122	4800
W34	486173	3873352	985	0.1	30.3	5.5	14.2	28.5	17.81	3.5	3203	4420

3– Sampling and Analytical Procedure

In order to study the quality variation of groundwater in the study area, 34 groundwater samples were collected from the pumping wells at the study area. Samples were collected with high density polyethylene (HDPE) bottles of one–liter capacity. In order to determination of different cations and anions concentration, methods such as ICP–OES, flame photometer and titration were done (Table 1).

At the time of sampling, the chemical and physical parameters of the water samples such as pH, EC, TH and TDS were measured using a Hach SensIon system. Model of SensIon is 156 multi–parameter following a standard operating procedure explained by California State Water Resources Control Board (2002). Several authors have reported results using this device (e.g., Suangkiattikum, 2005; Ermilio, 2005; Ikhu–Omoregbel *et al.*, 2005; Hunt *et al.*, 2006). Other parameters such as MAR, SSP, SAR, RSBC, PI, KR and Na% were analyzed in the laboratory. The analytical precision for the measured major ions was within ±5%. In order to study the quality of water, the obtained chemical data was evaluated in terms of its suitability for drinking, domestic and irrigation purposes. All samples were analyzed in applied research center of Geological Survey of Iran. The analytical data not only can be used for the classification of water for utilization purposes but also for ascertaining various factors on which the chemical characteristics of water depend (Sadashivaiah *et al.*, 2008). Statistical summary of the chemical data is listed in Table 2.

Table 2) Water chemistry analysis of groundwater samples in the study area.

P.	TH	SAR	K^+	Na^+	Mg^{2+}	Ca^{2+}	SO_4^{2-}	Cl^-	HCO_3^-	pH	TDS	EC
AVE	806.8	12.4	0.1	39.4	5.2	10.9	23.7	28.9	2.7	8	3447	5308.9
MAX	1980	28.87	0.51	116.7	22	24.1	70.5	96.2	4.55	8.45	9517	14280
MIN	170	3.98	0.00	7.43	0.6	1.8	3.94	3.1	1.3	7.15	480	1250
WHO	500	-	200	200	150	200	250	250	240	6.5-9.2	1000	1500
Units	mg/l	meq/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	μs/cm

4– Results and Discussion

4–1– Groundwater Chemistry

Among major cations, sodium was generally dominant representing on average 75.29% of all the cations. Calcium and magnesium ions were of secondary importance, representing on average 18.89% and 5.46% of all cations, respectively. Potassium ion was almost absent, representing on average 0.34% of all the cations. Among the major anions, the average concentrations of the chloride, sulfate and bicarbonate ions is 47.59%, 45.345 and 7.05% respectively. The order of anion abundance (water type) is $Cl^-> SO_4^{2-}> HCO_3^-$, contributing on average (mg/l), 52.27, 42.89 and 4.84% of the total anions, respectively. The EC varies from 1250 to 14280 μmhos/cm indicating that there are probably marginal (500–1500 μmhos/cm) and brackish water types (>1500 μmhos/cm) in the area. TDS ranges from 480 to 9517 with an average of 3446.4 mg/l. The maximum value of brine pH was 8.45 and minimum was 7.15. To determine the type of brine the measured cations and anions concentrations were plotted on a ternary diagram developed by Piper (1994) (Fig. 2). The diagram can be used to display the relative abundance of major anions and cations in dilute natural inflow waters and the concentrated brine of their associated closed–basin Lakes (Hardie and Eugster, 1970). Based on the plots on the Piper diagram (Fig. 2) the brine water type is currently $Na^+–Cl^-–SO_4^{2-}$ which is comparable with Maharlou Lake in Iran and Brystol Salt Lake and Great Salt Lake in the USA. Hydrogeochemical analyses of catchment waters showed that the difference of cations and anions is a cause for the different geological features (e.g. Jones and Decoampo 2004). The order of cations and anions abundance in the brine is: sodium, magnesium, calcium and potassium and chloral, sulfate and bio–carbonate respectively. Chemical analysis of input waters including runoff and groundwater indicate that the path of brine on the Eugster and Hardie flow diagram is II (Eugster and Hardie 1978), and after separation of different minerals, the brine type of the Lake is Na–Ca (Mg)–Cl, which is comparable with Maharlou, Brystol and Great Salt Lake in USA.

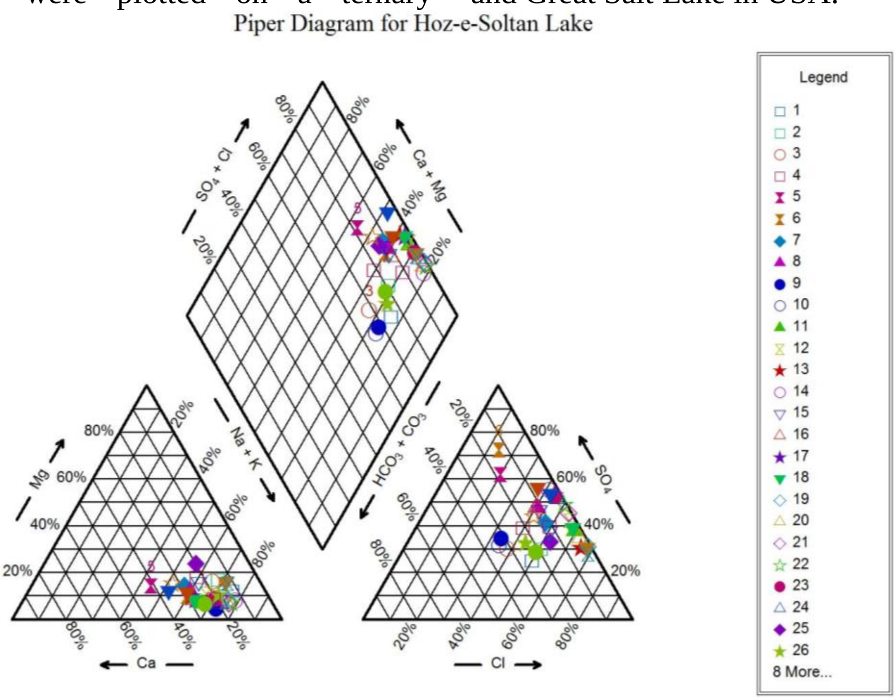

Figure 2) Piper diagram for essential cations and anions Hoz-e-Soltan Lake.

4–2– Water Quality Assessment

The classical use of water analyses in groundwater hydrology result in to produce information concerning the water quality. The water quality may yield information about the environments through which the water has circulated (Janardhana, 2007). The main objective following a hydrogeochemical assessment is to determine groundwater suitability to different uses based on different chemical indices. In this paper, assessment of the suitability for drinking and domestic consumption was evaluated using Schoeller diagram. Hydrogeochemical parameters of groundwater in the study are compared to the prescribed specification of World Health Organization (WHO, 2004) (see Table 2 and Fig. 3). The pH values of the groundwater vary between 7.15 and 8.45, indicating slightly alkaline to alkaline nature of groundwater.

According to the WHO (2004), the range of desirable pH values of water prescribed for drinking purposes is 6.5 – 9.2. There are no water samples with pH values outside of the desirable ranges. Table 2 shows that most of the parameters exceed the maximum permissible limits of WHO recommended standards (2004). The EC and concentration of TDS is more than the maximum permissible limits of 1500 μmhos/cm and 1000 mg/l respectively, in 76.47 (26 samples) and 64.70% (22 samples) of the total groundwater samples. According to Sawyer *et al*. (2003) classification for hardness, 67.64%, 32.36% of total groundwater samples are very hard (> 300 mg/l) and hard (150–300 mg/l) respectively (Table 3). Water hardness has no known adverse effects; however, hard water is unsuitable for domestic use. Depending on factors such as pH and alkalinity, a hardness of more than about 200 mg/l will lead to scale deposits in the piping system (N.G.F.M. van der Aa, 2003).

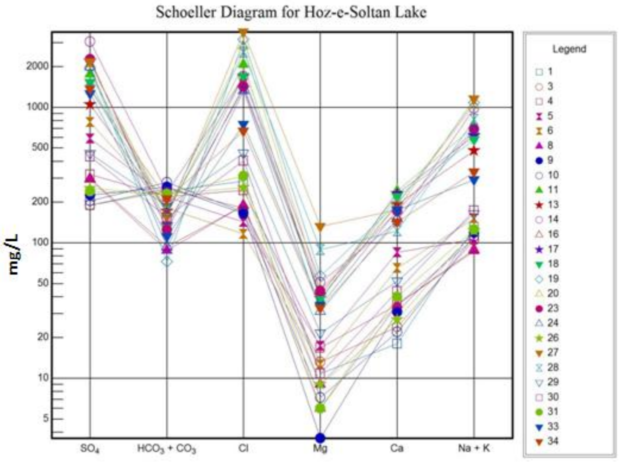

Figure 3) Schoeller diagram for Hoz-e-Soltan Lake samples.

Table 3) Groundwater classification based on total hardness

TH (mg/l)	classification	Sample number	Sample percent
<75	Soft	-	-
75-150	Approximately hard	-	-
150-300	Hard	11	32.36
>300	Very hard	23	67.64

4–3– Suitability for Irrigation Use

The water quality evaluation in the area of study was also carried out to determine their suitability for agricultural purposes. The suitability of groundwater for irrigation is depending on the effects on the mineral constituents of the water on both the plant and the soil. In fact, salts can be highly harmful. They can limit growth of plants physically, by restricting the taking up of water through modification of osmotic processes. Also salts may damage plant growth chemically by the effects of toxic substances upon metabolic processes. Salinity, sodicity and toxicity generally need to be considered when evaluating of the suitable quality of groundwater for irrigation (Todd, 1980; Shainberg and Oster, 1976). Parameters such as Na%, MAR, SSP, RSBC, PI, KI, SAR, EC and TDS were used to assess the suitability of water for irrigation purposes (see Table 4).

4–3.1– Salinity Hazard

Excess salt increases the osmotic pressure of the soil solution that can result in a physiological drought condition. Even though a field can appear to have plenty of moisture, the plants wilt because insufficient water is absorbed by the roots to replace that lost from transpiration. The total soluble salt content of irrigation water generally is measured either by determining its EC, reported in this paper as µmhos per centimeter, or by determining the actual salt content in parts per million (ppm). The EC values ranged from 1250 to 14280 μmhos/cm. The large variation in EC is mainly attributed to lithologic composition and anthropogenic activities prevailing in this region (Khodapanah *et al*., 2009). Normally, irrigation water with an EC of < 700 μmhos/cm causes little or no threat to most crops while EC of > 3000 μmhos/cm may limit their growth (Tijani, 1994). Based on the US Salinity Laboratory classification (1954), the salinity hazard for water samples in Hoz–e–Soltan Lake is classified as high (EC: 750–2250 μmhos/cm) and very high (EC: >2250 μmhos/cm) (Fig. 4). Most of the groundwater samples belong to very high and high salinity hazard (C4, C3) as per the salinity hazard classification in the basin. None of water samples had low and medium salinity contamination (Table 4). Groundwater that falls in the medium salinity hazard class (C2) can be used in most cases without any special practices for salinity control.

However, water samples that fall in the high salinity hazard class (C3) may have detrimental effects on sensitive crops and adverse effects on many plants. Such samples require careful management practices. Very high salinity water (C4) is not suitable for irrigation under ordinary conditions but may be used for salt tolerant plants on permeable soils with special management practices.

Table 4) Calculated statistical parameters for different groundwater samples index in studied area.

ID	MAR	PI	KR	SAR	RSBC	SSP	Na%	SAR	Class
W1	50	89.2	3.26	8.7	2.1	76.6	76.3	8.7	C3-S2
W2	52.3	79.8	2.23	7.7	1.27	69.2	68.9	7.7	C3-S2
W3	47.8	82.0	2.07	6.3	1.7	67.5	67.5	6.3	C3-S2
W4	44.4	71.7	1.55	5.5	0	60.7	60.8	5.5	C3-S2
W5	25.4	53.8	0.83	4.0	-5	45.7	45.3	4.0	C3-S1
W6	24.4	67.8	1.58	6.5	-3.6	61.4	61.0	6.5	C3-S2
W7	33.3	63.2	1.38	4.8	-2.5	57.9	57.9	4.8	C3-S1
W8	30.0	67.2	1.59	5.0	-2	61.4	61.4	5.0	C3-S1
W9	16.2	88.8	2.92	7.9	1.05	74.5	74.5	7.9	C3-S2
W10	35.3	91.7	2.96	7.7	2.35	74.8	74.6	7.7	C3-S2
W11	20.5	69.7	2.15	16.8	-21.4	68.3	68.2	16.8	C4-S4
W12	32.3	68.8	2.09	16.6	-19.1	67.7	67.5	16.6	C4-S4
W13	25.3	64.8	1.69	12.1	-16.5	62.9	62.8	12.1	C4-S4
W14	37.0	81.2	3.89	26.4	-10.7	79.6	79.5	26.4	C4-S4
W15	27.8	65.9	1.53	5.0	-2.4	60.4	60.4	5.0	C3-S1
W16	22.2	70.3	1.81	5.4	-2	64.4	64.4	5.4	C3-S2
W17	22.7	66.3	1.86	14.4	-20.9	65.0	64.9	14.4	C4-S4
W18	22.5	66.1	1.84	13.8	-19.9	64.8	64.7	13.8	C4-S4
W19	32.8	77.7	3.38	25.7	-18.2	77.2	77.1	25.7	C4-S4
W20	28.1	79.0	3.51	25.7	-16.4	77.9	77.8	25.7	C4-S4
W21	29.1	78.6	3.57	28.9	-21.8	78.2	77.9	28.9	C4-S4
W22	32.0	79.3	3.71	28.6	-18.7	78.8	78.5	28.6	C4-S4
W23	29.8	73.2	2.57	18.0	-15.2	72.0	71.9	18.0	C4-S4
W24	25.6	75.9	3.00	19.1	-13.6	75.0	74.9	19.1	C4-S4
W25	54.8	64.0	1.35	5.5	-1.2	57.6	57.3	5.5	C3-S2
W26	35.7	84.6	2.64	7.7	1	72.7	72.3	7.7	C3-S2
W27	55.6	73.4	2.64	23.5	-15.1	72.6	72.4	23.5	C4-S4
W28	54.8	74.5	2.72	20.0	-9.4	73.2	72.9	20.0	C4-S4
W29	40.9	68.9	1.67	7.0	-2.2	62.7	62.2	7.0	C4-S2
W30	29.0	77.3	2.51	8.8	-1.9	71.7	71.2	8.8	C3-S2
W31	20.0	80.7	2.27	7.2	-0.3	69.5	69.2	7.2	C3-S2
W32	31.8	60.4	1.13	4.1	-2.4	53.2	52.7	4.1	C3-S1
W33	24.8	55.1	1.14	7.8	-15.7	53.4	53.2	7.8	C4-S3
W34	27.9	64.1	1.54	9.6	-10.7	60.6	60.5	9.6	C4-S3

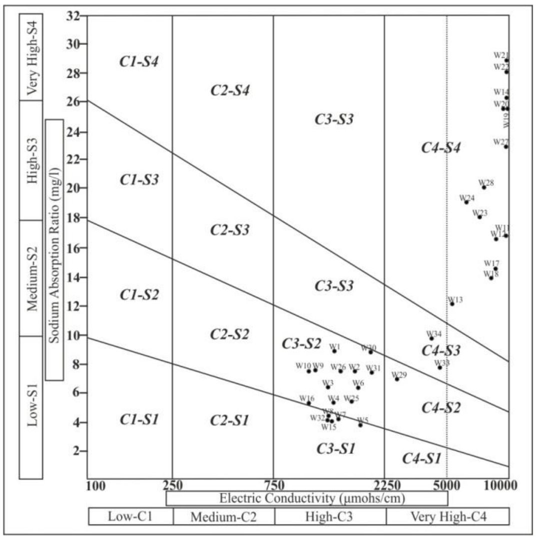

Figure 4) Salinity diagram for classification of irrigation waters (from Richards, 1954).

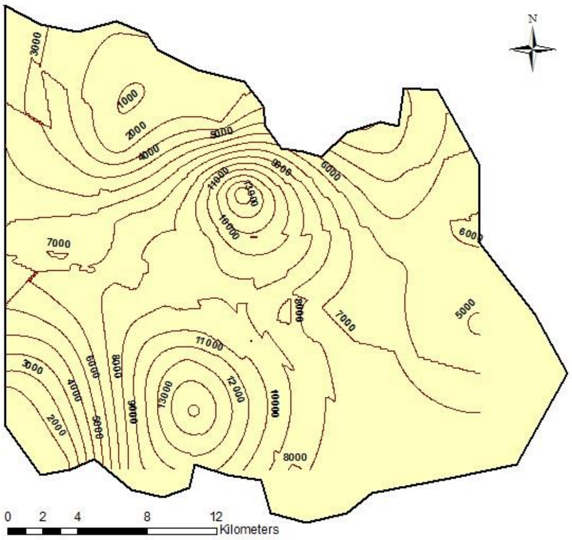

*Figure 5**)** The spatial distribution of EC in the groundwater.*

4–3.2– Alkali Hazard

Although sodium contributes directly to the total salinity the main problem with a high Na^+ concentration is its effect on the physical properties of soil. While a high salt content (high EC) in water leads to formation of saline soil, SAR leads to development of an alkaline soil. Irrigation with Na–enriched water results in ion exchange reactions: uptake of Na^+ and release of Ca^{2+} and Mg^{2+}. This causes soil aggregates to disperse thereby reducing its permeability (Tijani, 1994). The Na^+ alkali hazard in the use of water for irrigation is determined by the absolute and relative concentration of cations and is expressed as the SAR. There is a significant relationship between

Figure 5, shows spatial distribution of EC in the groundwater. It can be seen that from the north, east and west to the center and south of the studied area, EC values increases. Increasing of the soluble mineral materials along flow path, groundwater movement through salt flat zone of playa and evaporation are the major causes of salinization in eastern and northeastern zones of the Hoz–e–Soltan Lake plain. Moreover, irrigation with saline water, dissolution of the chemical fertilizers by irrigation water and industrial and municipal waste disposal also increases the rate of salinization in north and western parts of Hoz–e–Soltan Lake plain (Rouabhia *et al.*, 2009; Andradea *et al.*, 2008).

SAR values of irrigation water and the extent to which sodium is absorbed by the soils. Continued use of water with a high SAR value leads to a breakdown in the physical structure of the soil caused by excessive amounts of colloidally absorbed sodium. This breakdown results in the dispersion of clay soil that causes the soil to become hard and compact when dry which increases impervious to water penetration due to dispersion and swelling when wet. Fine–textured soils, those high in clay, are especially subject to this action (Khodapanah *et al.*, 2009). The calculated SAR values of the groundwater in the study area range from 4 to 28.89. As per the Richard (1954) classification based on SAR values (Table 3), 20 samples (58.82%) are in the excellent category because none of the samples exceeded SAR value of 10 (Table 3). Six samples (17.65%) fall in the medium alkali hazard category (S2), while 8 samples (23.53%) belong to the high and very high salinity hazard category.

4–3.3– Sodium Content

Sodium in irrigation waters is also expressed as Na% or SSP. The values of Na% in the study area range from 45.3 to 79.5%. It is observed that about 29 samples have high sodium percent (above 60%) and are therefore not suitable for irrigation purposes (table 5). High percentage of Na^+ with respect to (Ca^{2+}, Mg^{2+}, Na^+) in irrigation water causes deflocculating and impairing of soil permeability (Singh *et al.*, 2008).

Table 5) Classification of irrigation quality based on Na%.

Na%	classification	Sample number	Sample percent

< 20	Excellent	-	-
20-40	Good	-	-
40-60	Permissible	5	11.77
60-80	Suspicious	29	88.23
> 80	Inappropriate	-	-

4–3.4– Water Classification

In order to classify the groundwater samples for irrigation uses, the salinity hazard, sodium content, EC, SAR and SSP values have been used (see Table 4). Electrical conductivity values measured in the groundwater samples ranges between 1250 and 14280 μmhos/cm and the calculated SAR values varies from 4 to 28.89 in the study area. Results in Table 3 show that 14 samples (41.17%) are confined in C4–S4, 12 samples (35.30%) are in C3–S2, 5 samples (14.70%) are in C3–S1, 2 samples (5.88%) are in C4–S3 and 1 sample are in C4–S2. Due to low sodium and medium salinity groundwater C2–S1 class can be used for irrigation on almost all soils with little danger of sodium problem, if a moderate amount of leaching occurs. Groundwater in C4–S4 class is generally not suitable for irrigation. Salinity in C3–S2, C4–S3 and C4–S4 classes is high and very high respectively. It will result sodium problem in most soils and therefore not suitable for irrigation under ordinary conditions. This water can however be used on soils with considerable drainage. But even with adequate drainage, special circumstances for salinity control may be required. According to Table 4 and Figure 5, most of samples are in C4–S4 and C3–S2 classes thereby making the water unsuitable for irrigation purposes. The SSP values vary from 45.7 to 79.6%. Because the majority of samples exceed the allowance limit of 60%, it can therefore be concluded that the water in study region is not appropriate for irrigation purposes.

5– Conclusions

The groundwater quality of Hoz–e–Soltan Lake has been evaluated for its chemical composition and suitability for drinking, domestic and irrigation uses. The investigation indicates that among major cations, Na^+ is generally dominant representing on average 75.29% of all the cations. The order of anion abundance is $Cl^- > SO_4^{2-} > HCO_3^-$. The EC varies from 1250 to 14280 μmhos/cm indicating that there is probably marginal water and brackish water types in the area. According to the Piper diagram, the brine water type is currently Na^+–Cl^-–SO_4^{2-} which is comparable with Mahrlou Lake in Iran and Brystol Salt Lake and Great Salt Lake in the USA. TH average values equal to 806.8 mg/l the water lies in hard (150–300 mg/l) and very hard (> 300 mg/l) water classes which make it unsuitable for drinking, domestic and irrigation use. Alkali hazard also is classified from excellent (58.82% of samples) to medium (17.65% of samples), high and very high (23.53% of samples). Results show that about 29 samples have high sodium percent (above 60%) and are therefore not suitable for irrigation purposes. Increasing soluble mineral materials along the flow path, groundwater movement through salt flat and evaporation are the major causes of salinization in eastern and northeastern zones of the Hoz–e–Soltan Lake plain. Moreover, irrigation with saline water, dissolution of the chemical fertilizers by irrigation water and industrial and municipal waste disposal increases the rate of salinization in north and western parts of Hoz–e–Soltan Lake plain. Based on high salinity, SAR, TH, TDS, EC, SSP and Na% values in most water samples, the water is not recommended for drinking, domestic and irrigation uses.

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