Hydrogeochemical and isotopic assessment to determine hydraulic connection in the Izeh complex karstic area, Khuzestan province, southwest Iran

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PROBLEM :

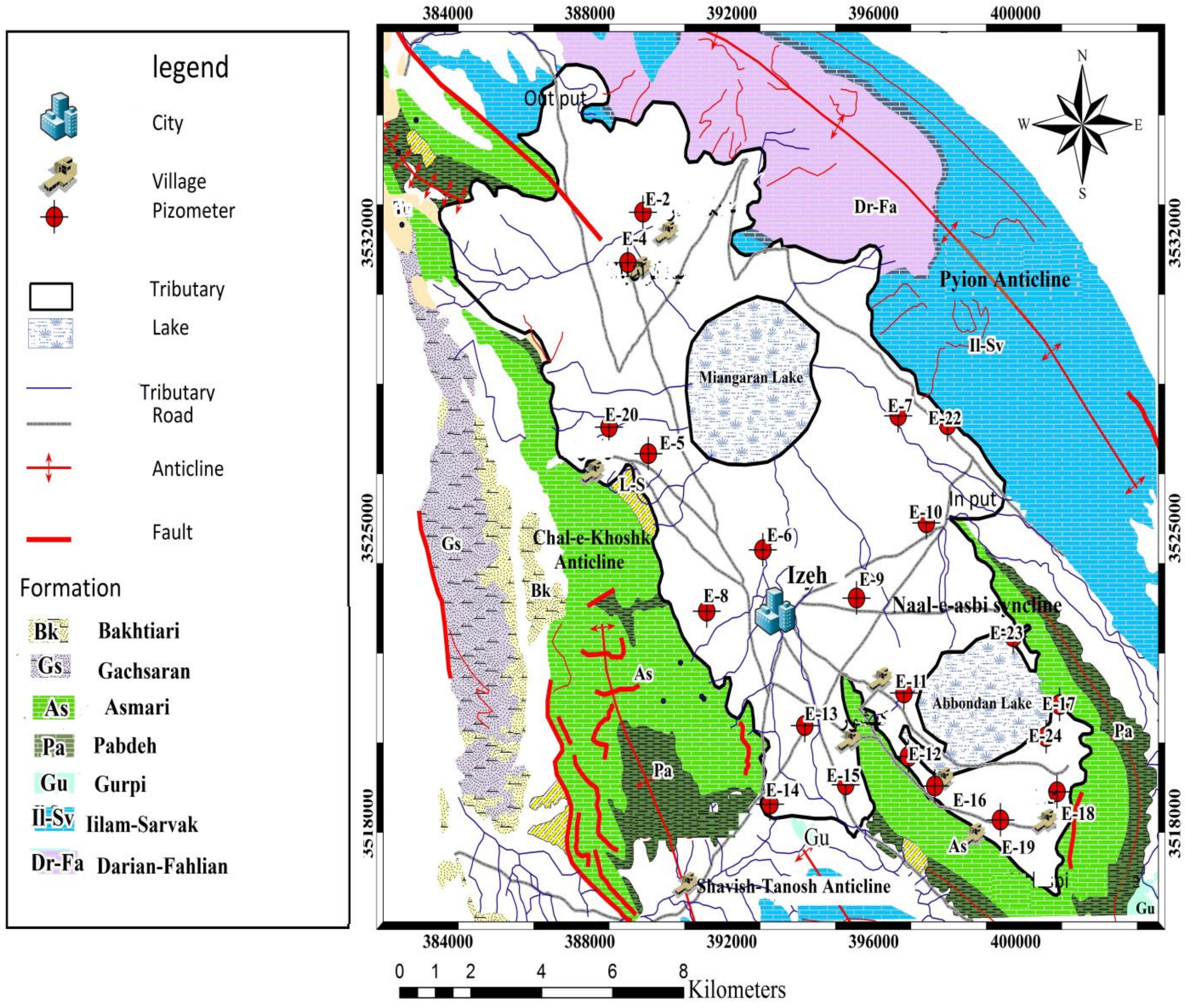
- Shortage of drinking water in the area, because water deficiency is a fundamental issue faces the population of the area and water supply for Izeh City population is every year Challenge.

OBJECTIVE:

To find out hydraulic connection between karstic structures and the source of water

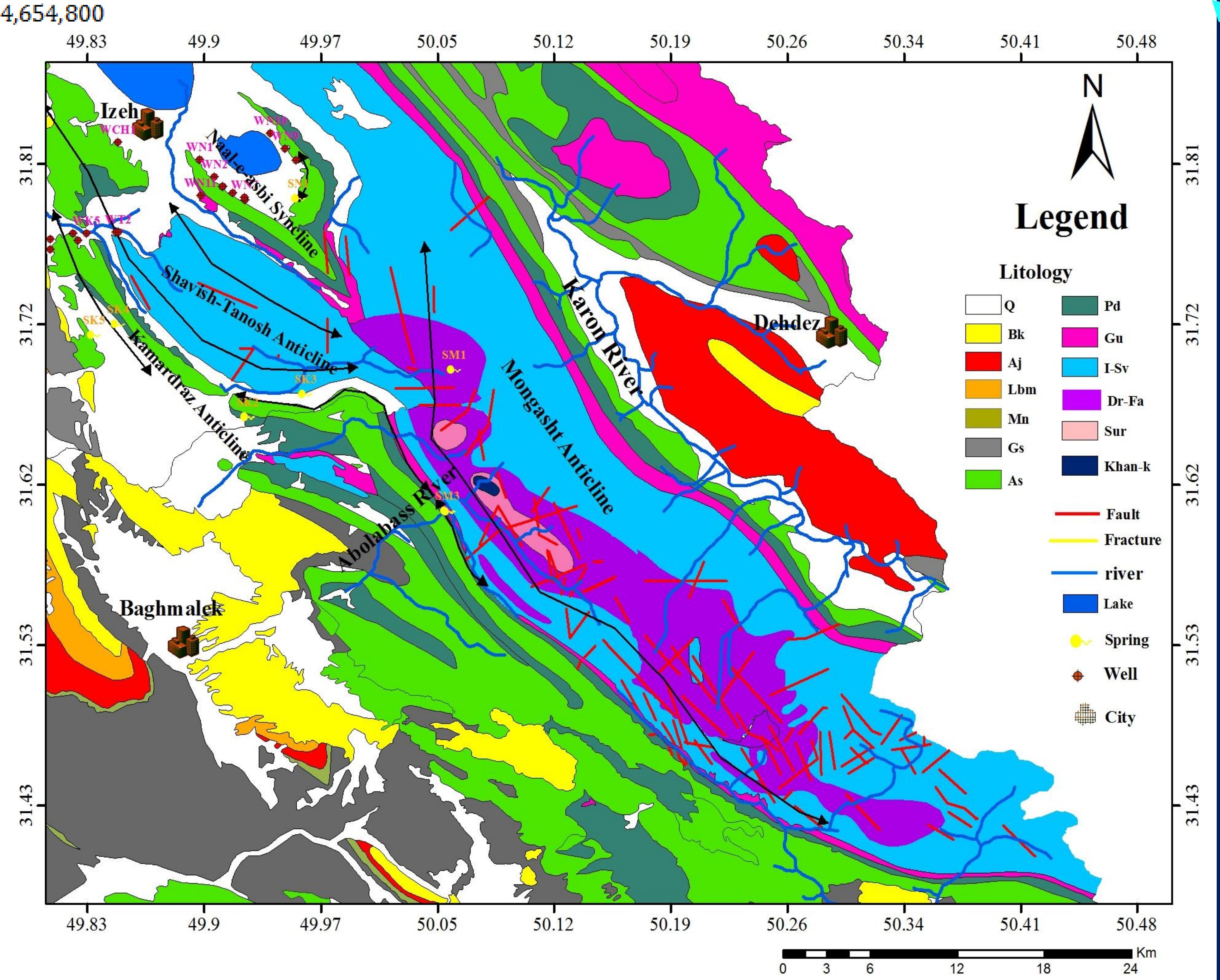
Study area:

The City of Izeh with 200/000 people is located in a tectonic open polje which covers 80 Km^2 and in spite of moderate rainfall (350 mm), is very poor aquifer due to lithologic nature (clay) of the area. So, the only source of water for drinking is water withdrawal from the karstic aquifers.



The mean annual temperature is 20.7°C

The average annual real evapo-transpiration is 1,632 mm.



From the geological point of view, the study area is situated on the southern flank of the folded Zagros domain in the Zagros Mountain Range.
The main exposed geological formations in the area with respect to age include Daryan-Fahlian lime stone (lower cretaceous), Ilam-Sarvak lime stone-dolomitic (upper cretaceous), Asmari lime stone (Oligocene to Miocene) and the shaly-Marly Pabdeh-Gorpi formation (upper Cretaceous to Eocene). Majority of the geological structures (folds and fault), including Kamarderaz, Mongasht, Shavish-Tanosh anticlines, and the Naal-e-asbi syncline are trending NW–SE

Mongasht

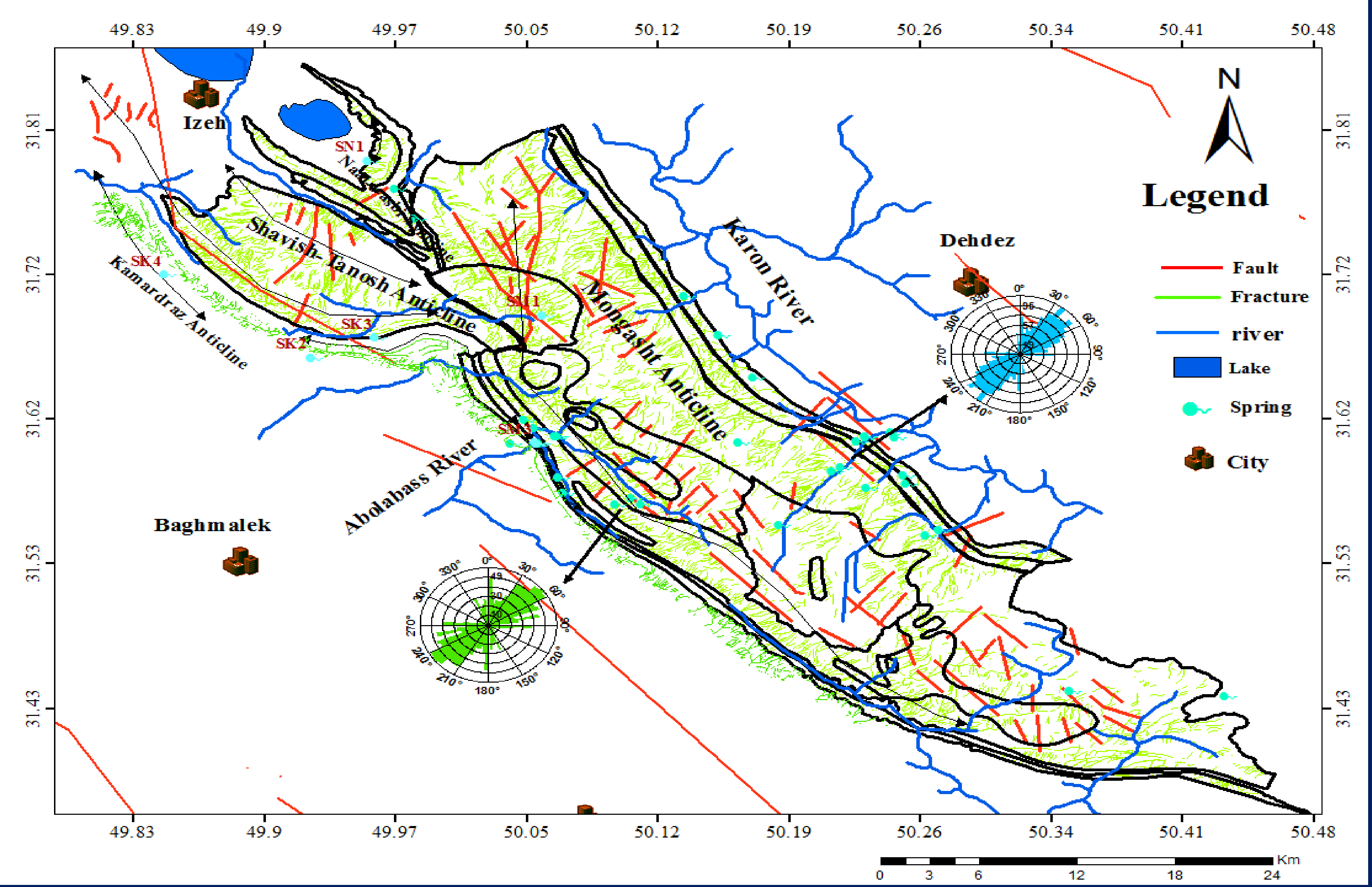
The Mongasht anticline trending NE-SW, is the largest structure in the area. Remarkable faults (more than 10 km) including the Kohsefid, Sepran faults and the Mongasht thrust are located in the south-western part of the Mongasht anticline and playing a significant role for groundwater movement and hydraulic connection between the water bearing horizons like Kamarderaz, Shavish-Tanosh anticlines and the Naal-e-asbi syncline. The geological fractures at every scales occurred along with faults and these discontinuities provide the necessary permeability for migration and accumulation of groundwater.

Shavish -Tanoosh

The coupled (conjugated) Shavish-Tanosh anticlines directing NW-SE, composed of the Ilam-Sarvak limestone and the fracture density is moderately more in the eastern limb with respect to the western one.

Naal-e-asbi Synclinorium

The Naal-e-asbi symmetrically folded synclinorium extending 12 km with a width of 2 km in the NW-SE direction and can be divided into north and south sections (Fig.1). This synclinorium is located between the Pion anticline in the north and the Shavish-Tanosh anticline in the south and this is the main and accessible place for groundwater extraction in the Izeh area.



Hydrotectonic map of springs. This map shows the function of faults and fractures in Izeh region and the location of springs

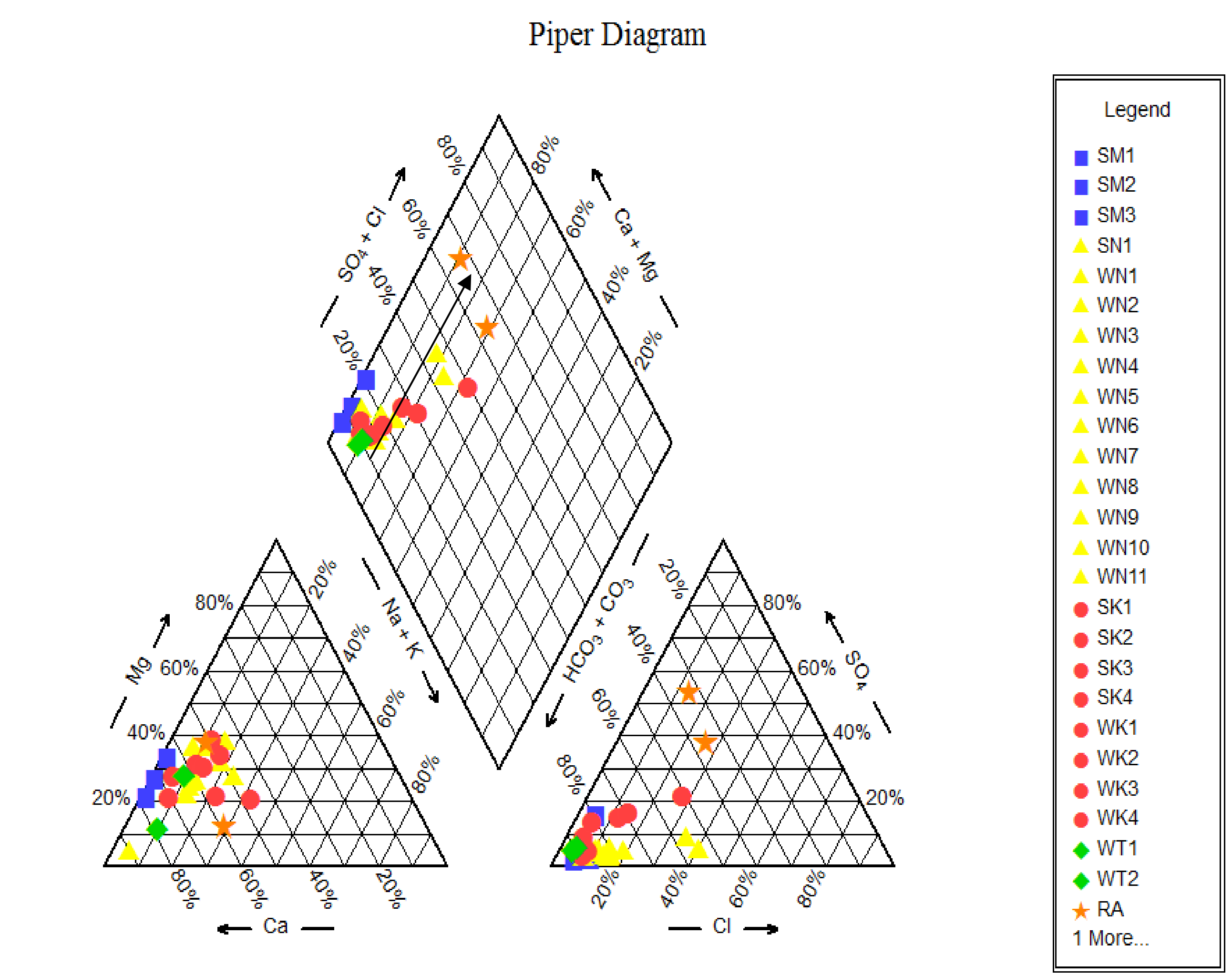
Materials and methods

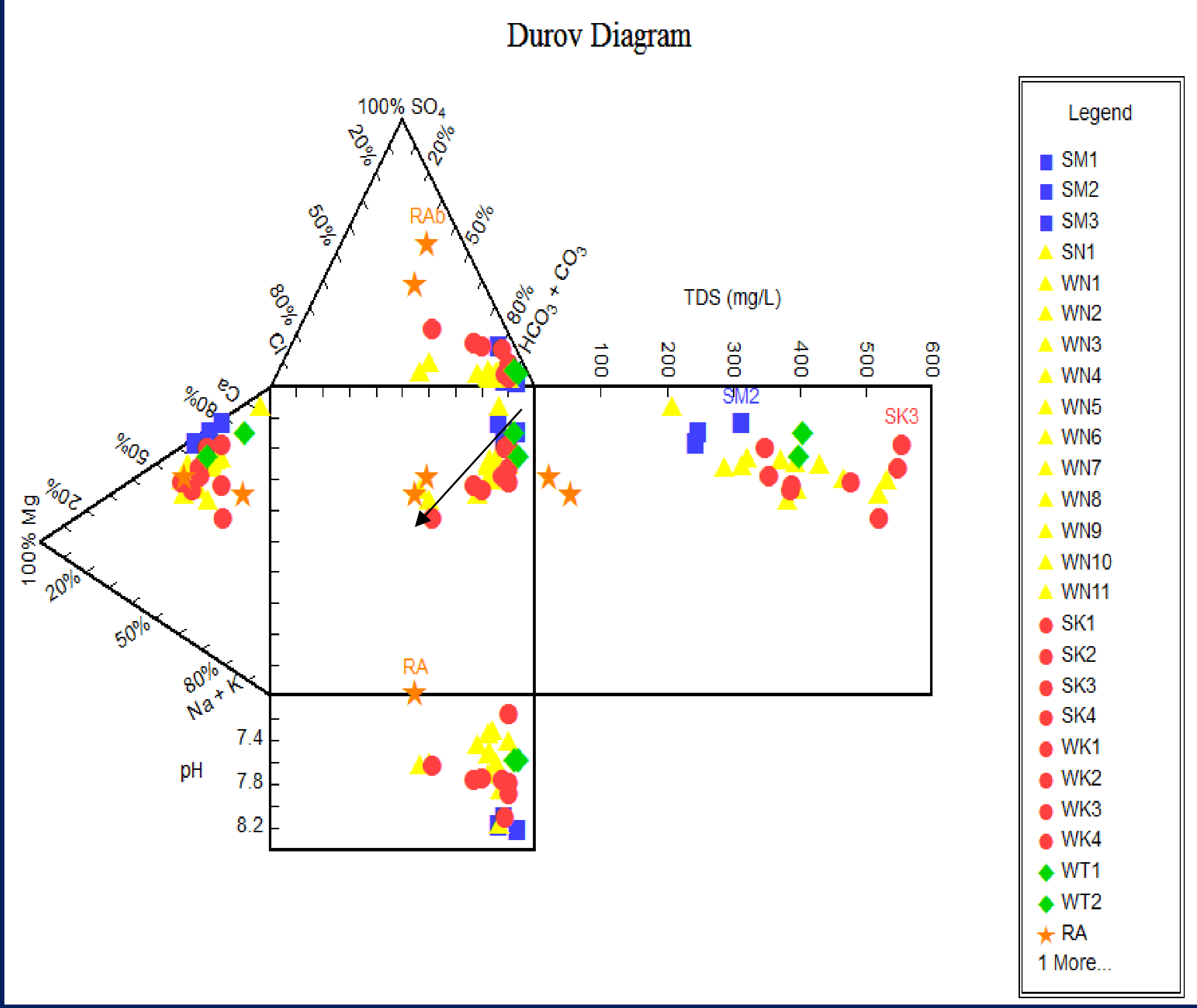
A total of 25 groundwater (17 wells and 8 springs) and 6 rain water samples were collected in wet season in January, 2020. The samples analysed for major, minor element and stable isotopes.

The hydrochemical properties of groundwater samples are shown in Table 1. The pH of groundwater samples is slightly alkaline and varies from 7.18 to 8.22. The temperatures were generally close to the ambient temperature, and vary from 12.8 to 24.8°C with a mean value of 19 °C. The measured groundwater electrical conductivity (EC) and total dissolved solids (TDS) of the samples varying from 278 to 1325 μS/cm and 209 to 944 mg/l, respectively.

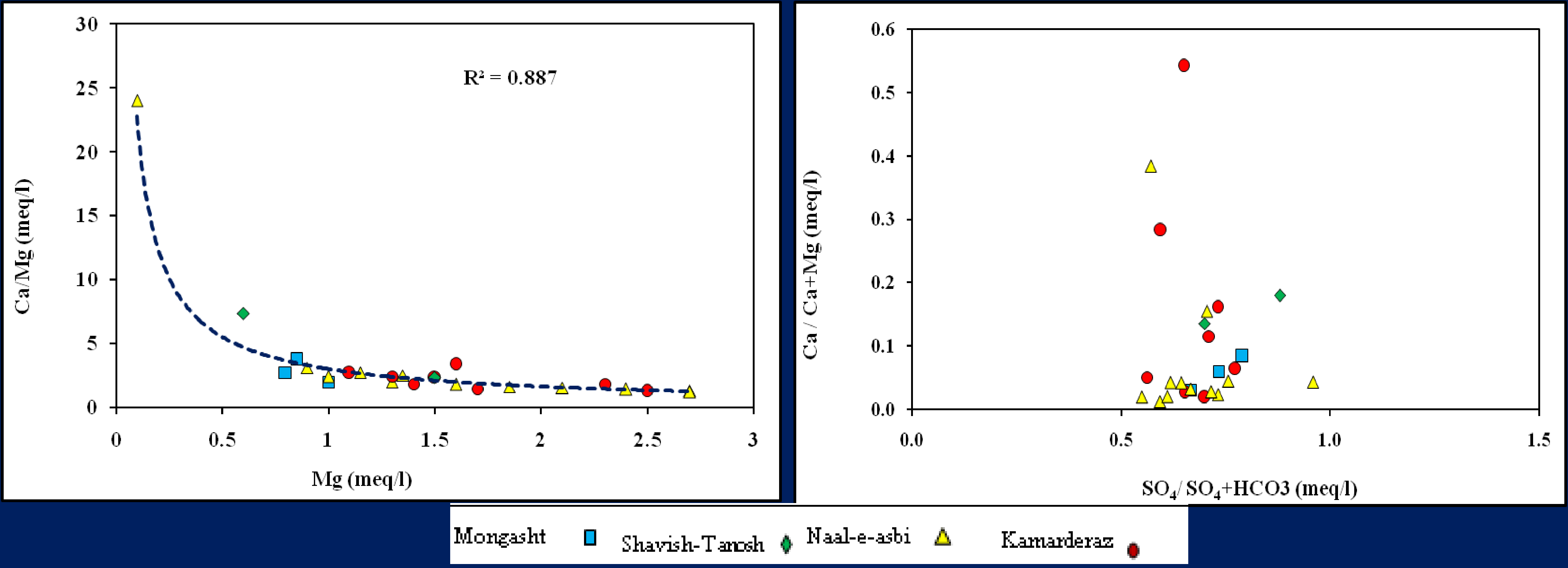
Table 1: Physico-chemical characteristics of the main karst springs and wells in the Izeh area (mg/l).

Name	Structure	ID	Ca	Mg	Na	K	HCO_3	SO_4	Cl	TDS	EC µS/cm	pH
Aghgil	Rain	$Rain_A$	3.607	1.58	0.6897	0.391	9.153	7.205	1.418	22.5	35	6.6
Abkhogan		$Rain_{AB}$	9.218	1.094	5.058	0.391	19.53	12.97	6.736	54.97	86	7
Abgol	Mongasht	SM1	44.09	9.722	1.149	0.391	183.1	1.921	7.091	247.2	320	8.22
Malagha1		SM2	64.12	10.33	1.839	0.391	198.3	28.82	8.863	312.4	429	8.18
Malagha1		SM3	40.08	12.15	1.379	0.391	173.9	2.882	12.41	242.9	330	8.12
Takab	Naal-e-asbi	SN1	48.09	1.215	3.219	0.391	140.3	5.284	10.64	209	278	8.2
Kaldozakh		WN1	72.14	32.81	20.23	1.173	366.1	7.205	33.68	532.7	707	7.35
Gamoshi		WN2	70.14	29.17	19.77	1.173	308.1	7.205	31.91	466.9	674	7.37
Lavaii 1		WN3	48.09	12.15	13.1	0.391	195.3	5.284	14.18	288.2	377	7.89
Lavaii 2		WN4	66.13	32.81	27.82	1.173	335.6	12.01	46.09	521	744	7.48
Bardboran 1		WN5	56.11	10.94	13.56	0.391	216.6	7.685	17.73	322.7	471	7.65
Bardboran 2		WN6	63.12	13.98	14.71	0.782	250.2	4.323	26.59	373.3	498	7.55
Porarshad		WN7	68.13	16.41	16.55	0.782	259.3	5.764	28.36	394.9	551	7.56
Abrak		WN8	52.1	15.8	12.18	0.391	204.4	8.646	21.27	314.5	469	7.75
Kobad 1		WN9	60.12	22.48	25.29	1.173	195.3	10.57	81.54	396.1	593	7.66
Kobad 2		WN10	58.11	19.44	33.34	0.782	186.1	19.21	65.59	382.3	582	7.65
Chega		WN11	66.13	25.52	11.04	0.782	308.1	4.803	15.95	431.8	584	7.44
Tekyeh 1	Kamarderaz	SK1	86.17	27.95	19.08	1.173	381.4	19.21	14.18	548.5	716	7.18
Tekyeh 2		SK2	64.12	30.38	17.7	1.173	329.5	24.02	12.41	478.7	626	7.8
Abgorazi		SK3	109.2	19.44	14.71	1.173	381.4	9.606	19.5	554.5	782	7.9
Monareh		SK4	64.12	15.8	7.127	0.782	238	8.646	14.18	348.3	455	8.12
Number 1 rostaii		WK1	70.14	18.23	55.41	1.564	231.9	72.05	70.91	519.8	721	7.65
Number 2 Halayegan		WK2	50.1	20.66	19.08	1.173	238	36.02	23.04	387.6	542	7.76
Number 3 Halayegan		WK3	52.1	17.01	14.71	0.782	231.9	28.82	8.863	353.8	451	7.78
Number 4 Halayegan		WK4	60.12	13.37	26.21	1.173	222.7	38.43	26.59	388.3	528	7.77
Number 5 Tangsofla	Shavish-Tanosh	WT1	70.14	18.23	11.95	1.173	280.7	9.606	7.091	398.4	500	7.61
Number 6 Tangsofla		WT2	88.17	7.291	12.64	1.173	274.6	12.01	8.863	404.4	500	7.61



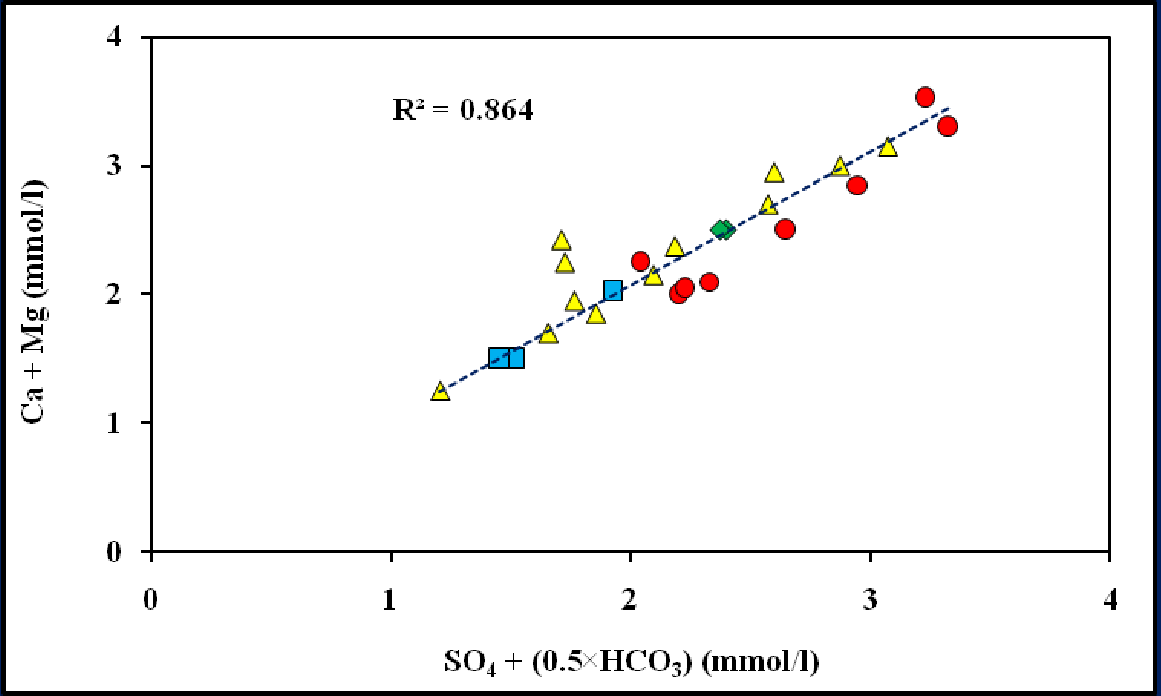


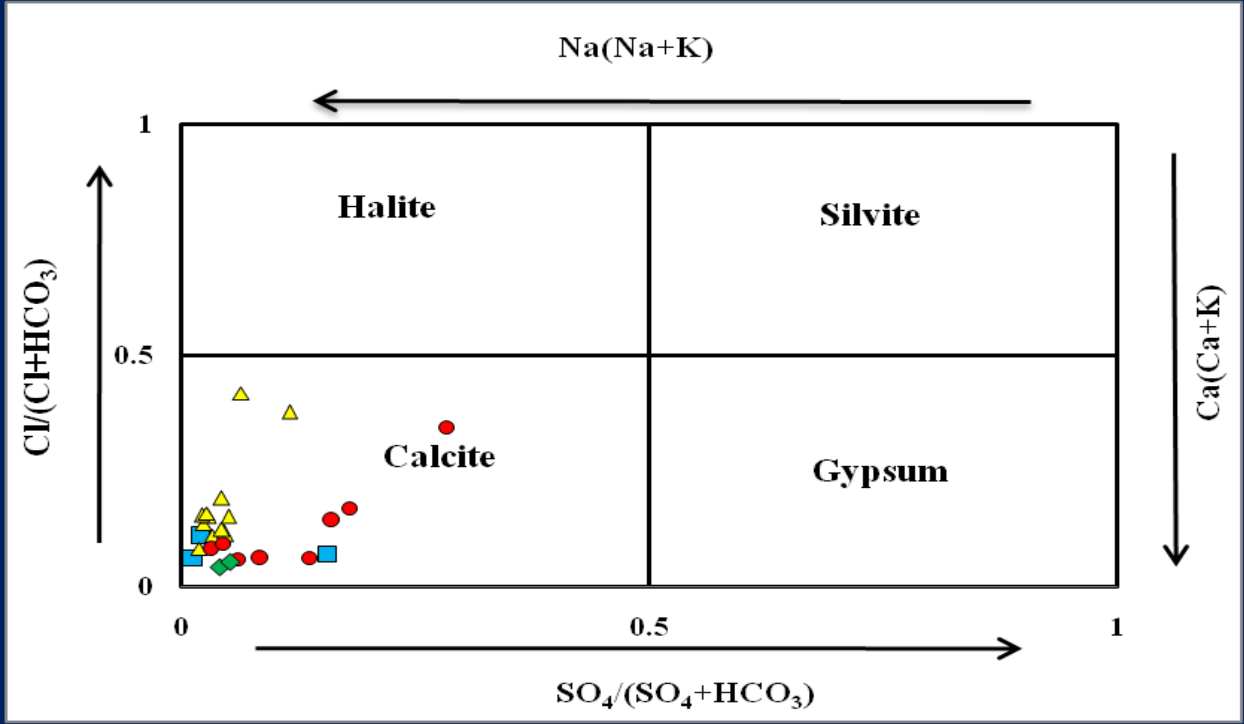
The Piper Trilinear diagram was utilized to determine hydrochemical facies and groundwater quality classification of the Izeh Catchment based on the major cations and anions, (Ca^{+}, Mg^{+} , Na^{+} , K^{+}, HCO_3^{-}, $SO_4\ ^{2-}$ and Cl^{-}). As the groundwater in the study area accumulate and flows in the carbonate rocks exhibiting $Ca–HCO_3$ water type and all of the samples forming a cluster.

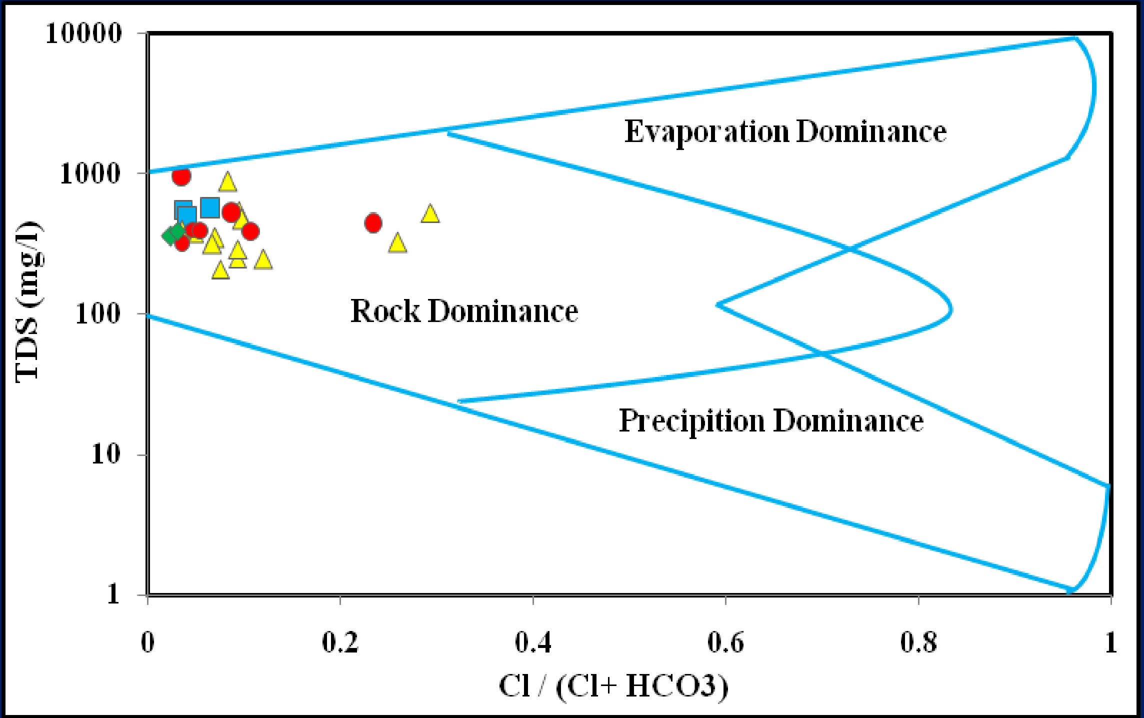


The ratio of Ca^{2+} / Mg^{+2} ratio is low in dolomit rocks (2.9) and high in limestones (11.8). For the samples of the region, it is about 2.3, which indicates that the water originates from the calcareous dolomite rock (Ilam Formation - Sarvak anticline of Mangesht).

with increasing magnesium concentration, the ratio of calcium to magnesium decreases, as well as the ratio of $Ca^{2+}/Ca^{2+}+Mg^{2+}$ between 1 and 0.5, which indicates that groundwater sources have reacted more with dolomite and their origin is dolomite formation.

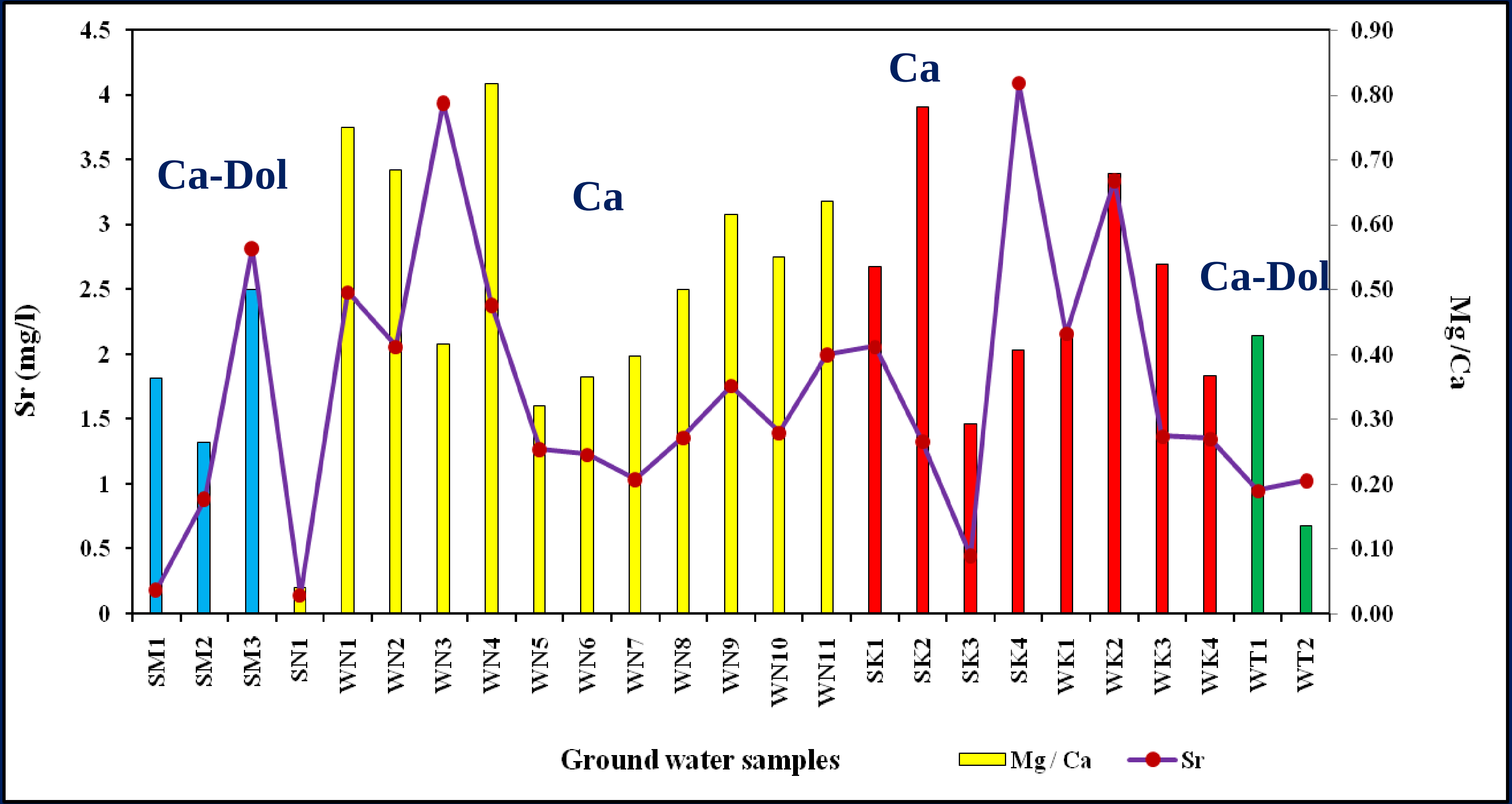






The Gibbs diagrams (Gibbs, 1970) depicting log TDS against both the ratios of cations Na^+/ (Na^+ + Ca^{2+}) and the ratio of anions Cl^-/(Cl^- + HCO_3^-) are widely used to understand relative importance of the major natural controlling mechanisms of groundwater chemistry .The plotted samples in the Gibbs diagrams show that the pattern of the samples is concentrated in the rock dominance zone

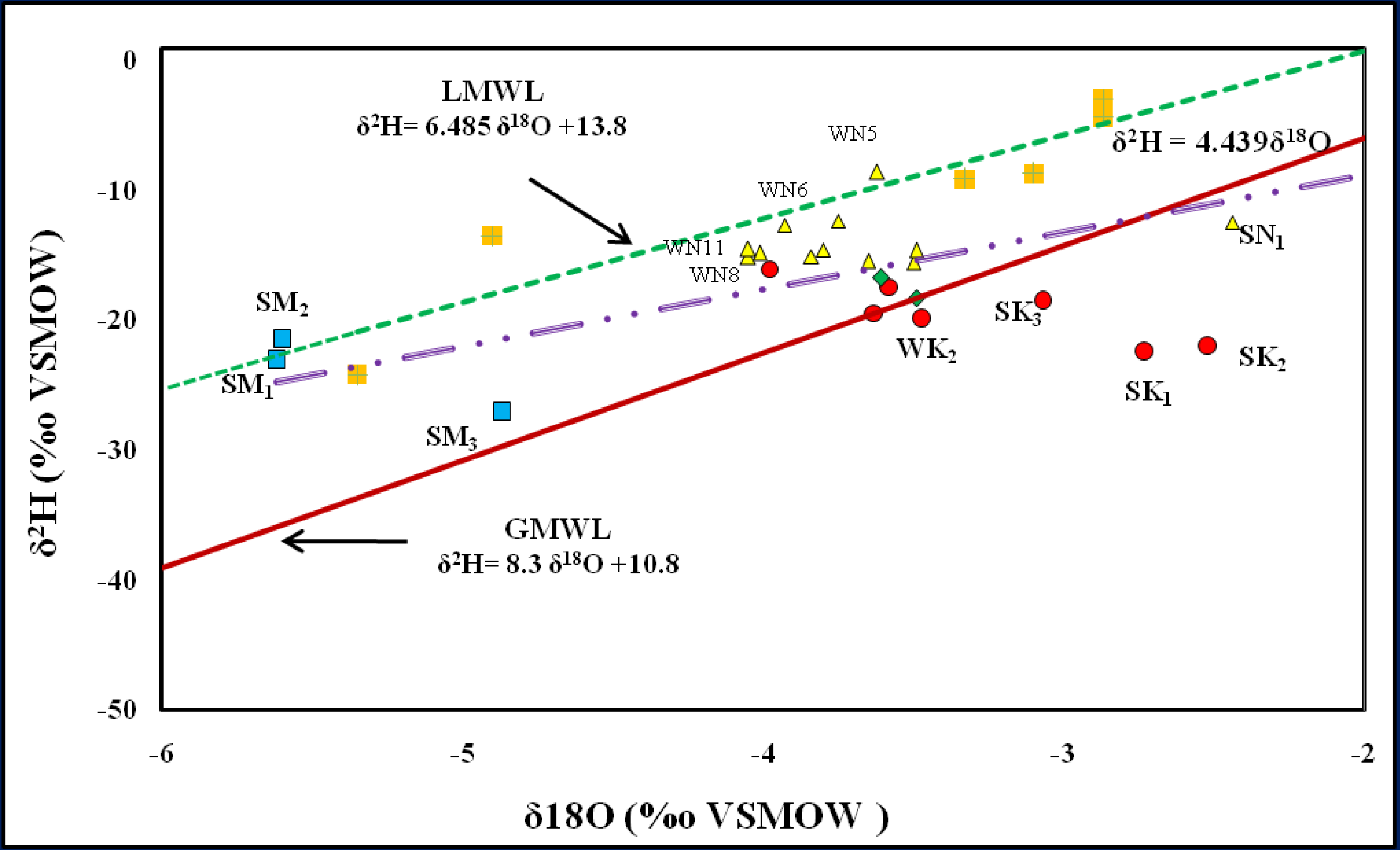
Relationship between structures using major and minor elements



The Mg^{+2}/Ca^{+2} ratio and Sr concentration of the groundwater samples in the area

Table 2:Isotopic values and temperature values (‰) of spring and groundwater samples

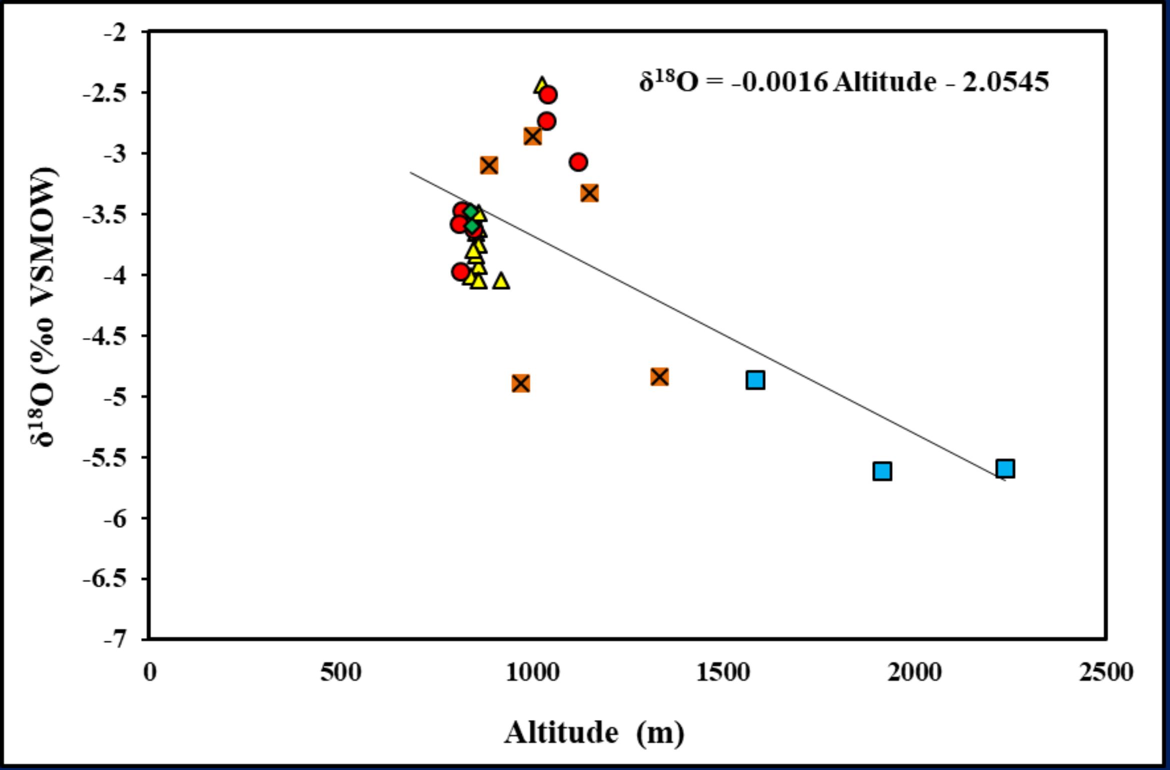
NO	Samples	δ^2H	$\delta^{18}O$	d-excess	T°C	Altitude
1	RA	-9.11	-3.33	17.53	12.9	1153
2	RAB	-24.14	-4.85	24.66	12.1	1334
3	RB	-4.32	-1.87	10.64	14.1	681
4	RK1	-8.68	-3.1	13.4	12.4	889
5	RK2	-2.9	-2.87	15.06	13.4	1003
6	RT	-13.45	-4.9	13.15	9.5	973
7	SN_1	-12.42	-2.44	7.1	18	1027
8	WN_1	-15.44	-3.65	13.76	23	853
9	WN_2	-15.54	-3.5	12.46	23	847
10	WN_3	-12.29	-3.75	17.71	22	861
11	WN_4	-14.58	-3.49	13.34	22	861
12	WN_5	-8.57	-3.62	20.39	21	859
13	WN_6	-12.65	-3.93	18.79	22	862
14	WN_7	-14.79	-4.01	17.29	21.5	839
15	WN_8	-15.13	-4.05	17.27	22.9	861
16	WN_9	-15.04	-3.84	15.68	23.7	853
17	WN_{10}	-14.53	-3.8	15.87	17.8	845
18	WN_{11}	-14.5	-4.05	17.9	16.5	920
19	SM_1	-23.04	-5.62	21.92	12.8	1915
20	SM_2	-21.47	-5.6	23.33	18	1218
21	SM_3	-27.06	-4.87	11.9	20	1211
22	WK_1	-16.02	-3.98	15.82	24.6	815
24	WK_2	-19.87	-3.47	7.89	22.7	819
25	WK_3	-19.37	-3.63	9.67	24.7	847
26	WK_4	-17.39	-3.58	11.25	23.2	810
27	SK_1	-22.4	-2.73	-0.56	24	1037
28	SK_2	-21.97	-2.52	-1.81	18	1041
29	SK_3	-18.48	-3.07	6.08	20.9	1121
30	WT_1	-18.24	-3.49	9.68	23.7	843
31	WT_2	-16.72	-3.61	12.16	23.7	844

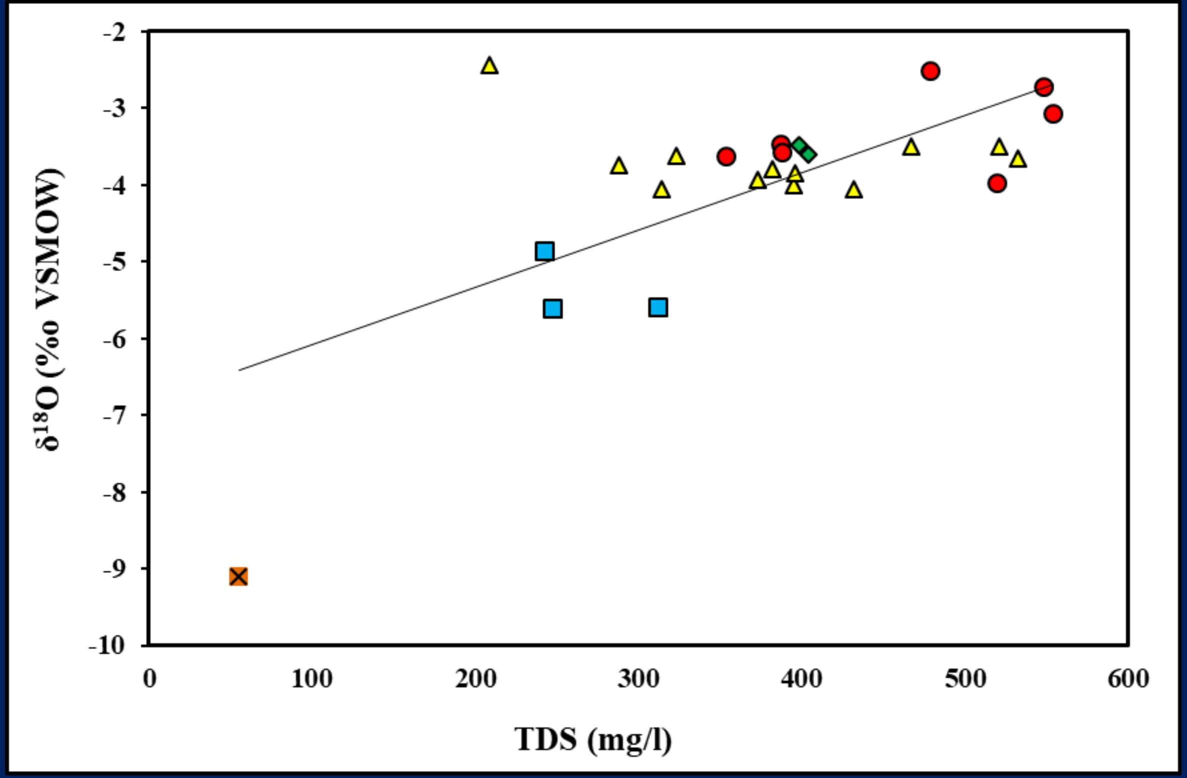


Position of isotopic composition of regional water resources in relation to the global meteoric water line (GMWL) and Izeh meteoric water line (LMWL)

According to the position of water samples in relation to the local and global isotopic line of Izeh harvested water samples on the $\delta^{18}O$ diagram relative to $\delta^{2}H$, all samples except (WN5)

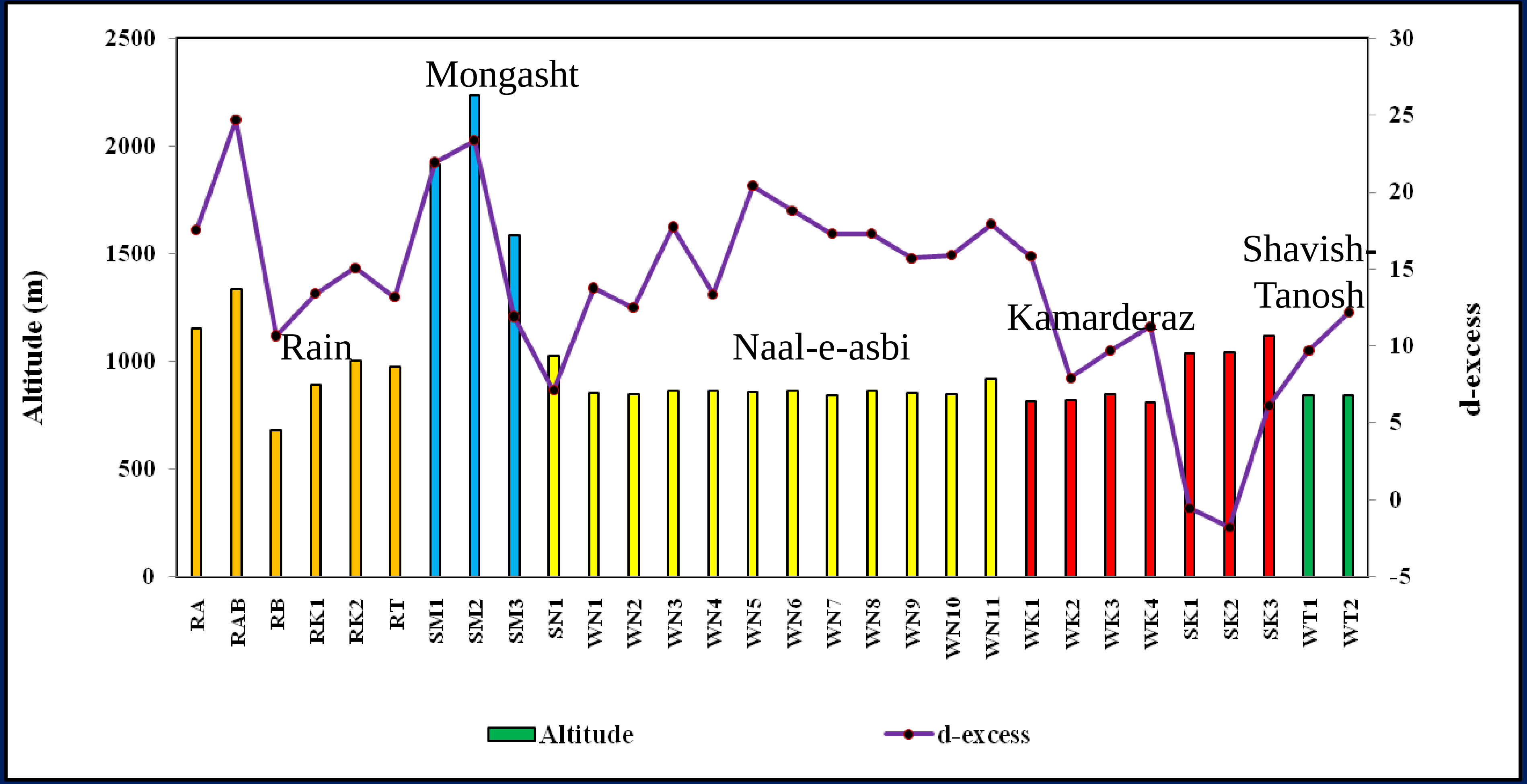
which is above the atmospheric line, were located on the right side of Izeh atmospheric line. The most important cause of isotopic enrichment is the effect of the evaporation process during the movement of water in the unsaturated zone and its transfer to springs and well.



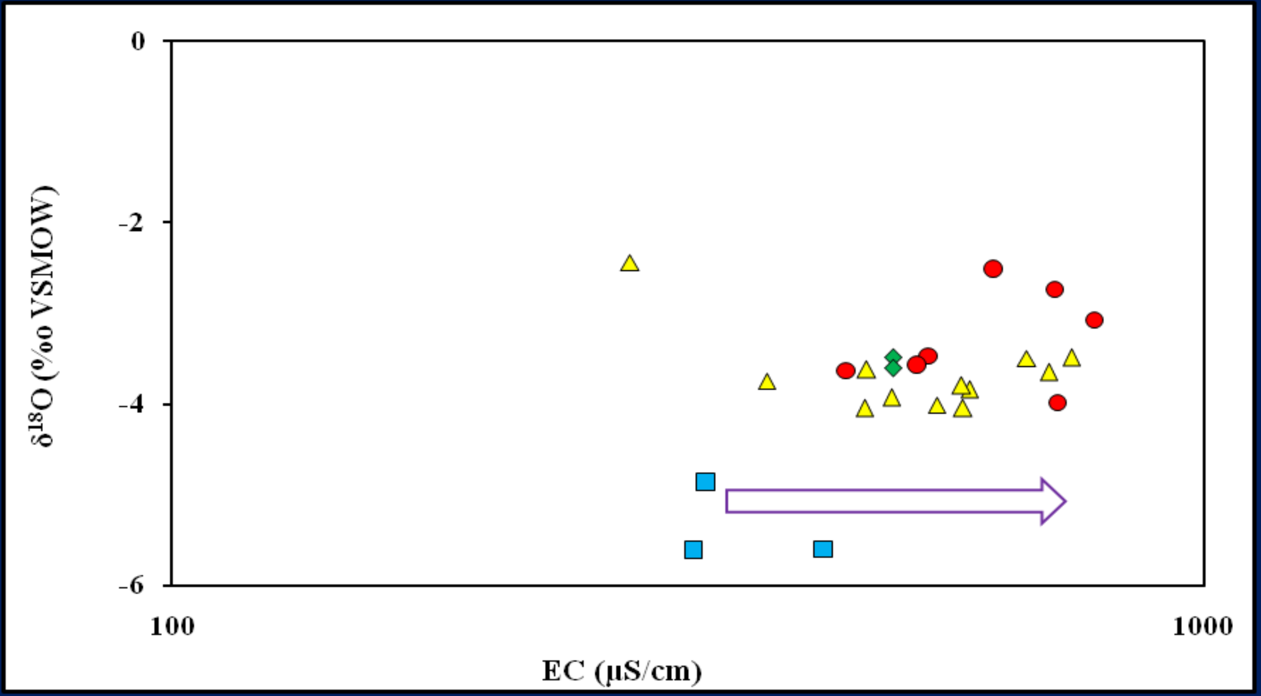


- **The isotope ratio of $\delta^{18}O$ shows significant correlation with elevation; There is also a correlation between $\delta^{18}O$ of Naal-e-asbi and Mongasht samples. The spring outlets with higher elevation (SM_1, SM_2 SM_3) exhibited the more depleted isotope composition.**

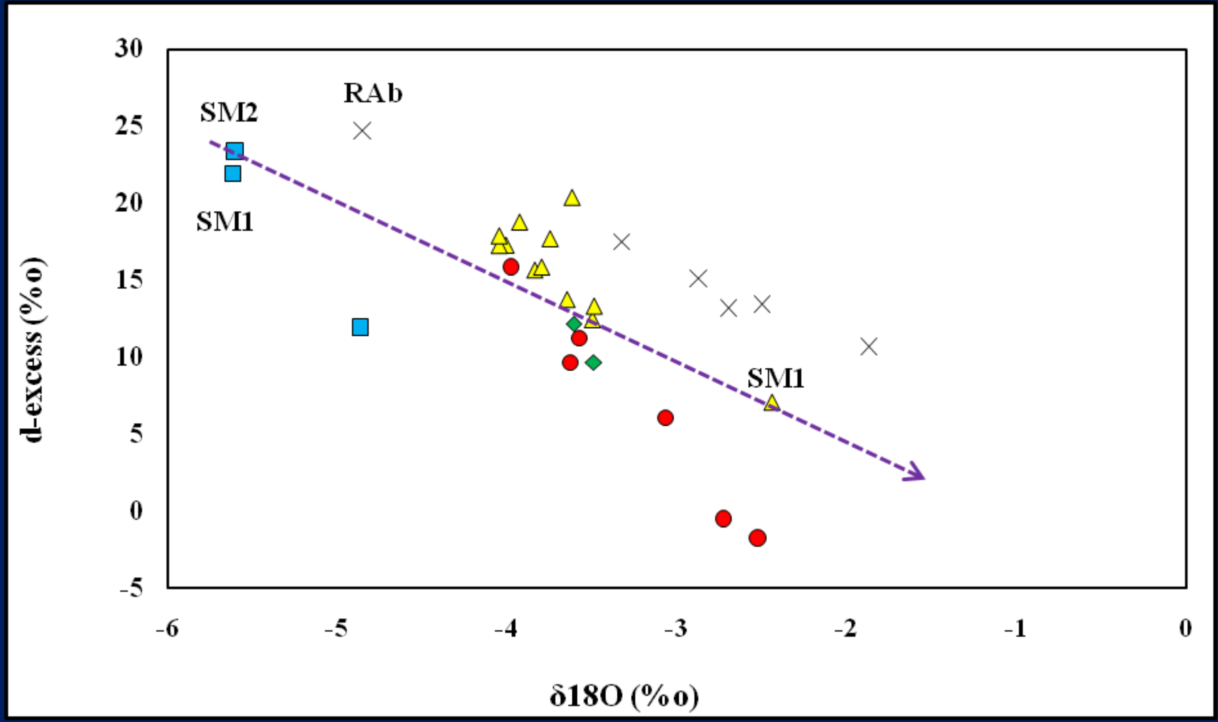
$\delta^{18}O$ increased in accordance with the increase of TDS value, that is, $\delta^{18}O$ increases in the groundwater flow direction (Mongasht to other structuers).



d-excess values increase with elevation and in this figure it is evident that the Monghshat with higher elevation containing higher d-excess.



Plot of δ^{18}O, and EC values indicates a good correlation between samples concerning source of recharge and probable interconnection of structures in the area.



The δ^{18}O, and d-excess values of groundwater samples reveals the connection between structures.

Conclusions:

Based on collected data including structural geology, major and minor ions and stable isotopes it was realized that;

1- there is a connection between the Mongashat anticline and other structures .

2- The Nal-e-asbi syncline and Shavish-Tanoosh anticline recharging from the Mongasht anticline.

3- Low feeding of the Nal-e-asbi syncline is occurring. from Mongashat anticline

4- In spite of relatively huge amount of water in the Shavish-Tanoosh anticline it is not well known, whether accumulated in depth or moves away from the area.


thanks for your attention