Characterization of balneological properties of Mahallat Thermal Springs, Central Iran

Charakterystyka właściwości balneologicznych uzdrowisk Mahallat w centralnym Iranie

Vahid Moeini[1], Farid Moore[2], Dr. Nghargbu K'tso[3]

[1]Geology Department, Esfahan Paiam Noor University, Esfahan, Iran
[2]Earth Science Department, Shiraz University, Shiraz, Iran
[3]Geology and Mining, Nasarawa State University, Niger

SUMMARY

Mahallat spas have been known for their healing properties for many years. It is told that these spas have cured many diseases such as skin lesion, rheumatic diseases, eczema, atherosclerosis, etc. There are six thermal springs in Mahallat district namely Shafa, Donbe, Soleimanie, Bakhtiary, Romatism and Hakim, five of which are used for balneological purposes. The major element chemistry of thermal waters in Mahallat is similar to that of waters uses at established balneological sites in other parts of the word. In this survey, balneological investigations are carried out on Mahallat spas and the composition of these spas are compared with some well- known spas in the world. Furthermore, the hydrology of these springs are studied using hydrochemistry. Results revealed that Mahallat thermal springs may be capable of healing skin diseases, rheumatism, goat, venereal diseases, gastro-intestinal disorders, cardio-vascular disorders and neurological disorders.

Key words: Balneology, Iran, Mahallat Thermal Springs, mineral water, spa.

STRESZCZENIE

Uzdrowiska w Mahallat od wielu lat znane są ze swoich leczniczych właściwości. Przypisuje się im wyleczenie schorzeń,takich jak: choroby skóry, choroby reumatyczne, wysypka, miażdżyca i wiele innych. W okręgu Mahallat istnieje sześć źrodeł termalnych, mianowicie Shafa, Donbe, Solimamie, Bakhtiary, Romatism i Hakim. Do celów balneologicznych wykorzystywanych jest pięć z nich. Podstawowy skład chemiczny źrodeł termalnych w Mahallat podobny jest do składu chemicznego miejsc wykorzystywanych balneologicznie w innych częściach świata. W badaniu tym, uzdrowiska w Mahallat poddano badaniom balneologicznym oraz przeprowadzono analizę porównawczą składu chemicznego tych uzdrowisk i niektórych znanych sanatoriów z innych części świata. Co więcej, hydrologia tych źrodeł badana jest za pomocą hydrochemii.Wyniki pokazały, że źrodła termalne w Mahallat mogą mieć zastosowanie w leczeniu chorób skóry, reumatyzmu, dny moczanowej, chorób wenerycznych oraz schorzeń gastroenterologicznych, sercowo-naczyniowych i neurologicznych.h.

Słowa kluczowe: Iran, uzdrowiska Mahallat, wody mineralne, SPA Balneologia,

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INTRODUCTION

Mahallat mineral water spring is located in Central Iran (fig 1). Its balneological history and use for curative purposes goes back to 16AC, when it is said that Shah Abbas of Safavie dynasty has used this spring for treating his foot lesion. Nowadays Mahallat spring is widely known for its ability in treating skin lesion, vetiligo, low back pain, rheumatism, and renal colic.

The main purpose of this paper is the determination of the balneological properties of Mahallat thermal spring and the comparison of its balneological properties with other parts of the word.

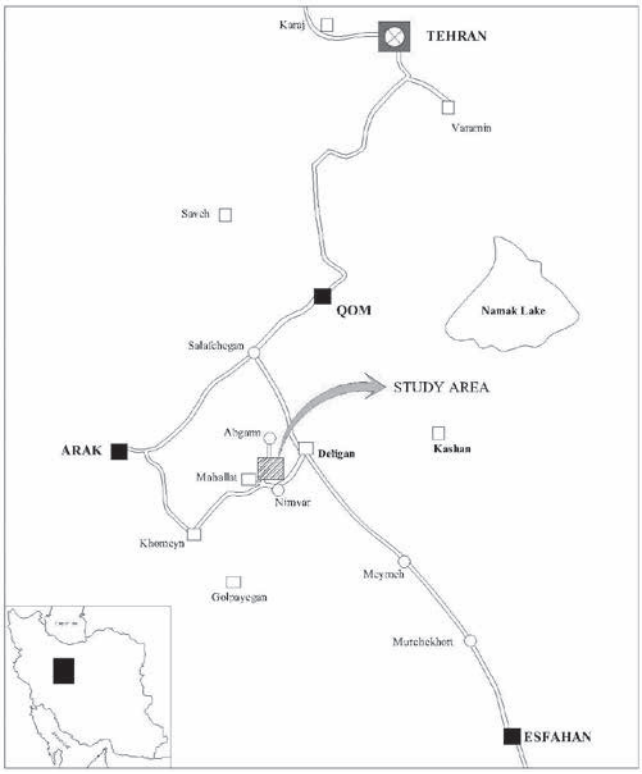


Figure 1. Location Map of the Study Area.

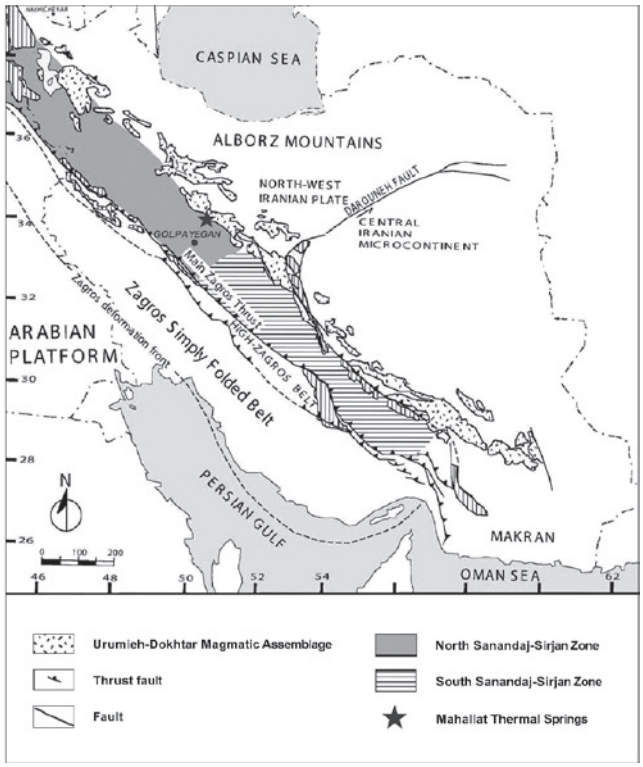


Figure 2. Main tectonic units of Iran and location of Mahallat Thermal Springs. The base map is from Ghasemi and Talbot 2006).

DESCRIPTION OF STUDY AREA

2-1. Geographical situation

Mahallat Thermal Springs are located between latitudes 33° 57´ N and 34° 4´ N and longitudes 50° 30´ E and 50° 37´ E. These springs are located in the southwest of Tehran with a distance of 30 kilometers from the west of Delijan and 15 kilometers from the northeast of town of Mahallat. The transit road of Isfahan-Tehran, which is the connecting way between the center of the country and the southeast and south of the country, is located on the eastern side of this region (fig. 1).

2-2. Geological setting

Mahallat in the Central Iran is a region with the occurrence of many thermal springs. These springs are located in the south-west of Urumieh-Dokhtar Magmatic Assemblage (UDMA) in an area between UDMA and the northern part of Sanandaj--Sirjan zone (fig. 2).

The geology of the study area comprises of several Precambrian, Permian, Mesozoic and Cenozoic lithologic units (fig. 3). The oldest unmetamorphosed series in the region is Kahar Formation (Precamberian) composed of shales and some sandstones. The formation is overlain by the Soltanieh Dolomite formation(Cambrian) with up to 1000 meters thick. A stratigraphic gap exists between the old and the young Paleozoic sediments and Permian beds directly overlie the Soltanieh and Kahar formations. This hiatus is caused by a significant erosional phase, and also orogenic folding preceding the deposition of the Permian sediments. Permian sediments are composed of thick-bedded to massive dolomite. Mesozoic units are represented by Triassic dolomite (Shotori Formation),

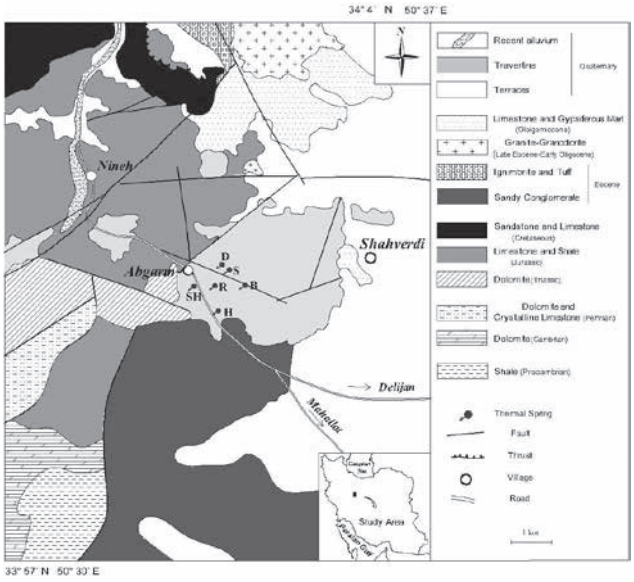


Figure 3. Geological map of the Mahallat Thermal Springs.

Jurassic limestone and shale with sandstone (Shemshak formation), and Cretaceous alternations of granular sandstone, quartzite sandstone, conglomerate, limestone and orbitolina bearing limestone. Tertiary strata beginning with conglomerates alternating with sandstones. The volcanic rocks (Eocene) consist of Ignimbrites and green acidic tuffs. Oligomiocene rocks with 300-400 meters thick composed of limestones and gypsiferous marls (Qom formation). Above mentioned

volcanic and Oligomiocene unit have been invaded by granite-granodiorite stock of the Siah Kuh (Miocene). This stock outcrops in more than 30 km^2 area and it is the closest pluton to the thermal springs. Quaternary travertines, which are the outcome of thermal springs activities , are exposed mostly next to the major faults and the crashed zones. Certain thermal springs are still active and this study focuses on them (Thiele et al. 1968).

MATERIALS AND METHODS

Mahallat thermal springs known as 'Abegarm-e-Mahallat' is used by visitors as spas. More than 500,000 tourists use these hot springs annually.

At first phase, six thermal springs namely Shafa, Donbe, Soleimanie, Soda (Bakhtiary), Romatism and Hakim were identified in the region. Shafa thermal spring with a flow rate of 40lit/s is the biggest thermal spring in the region which is run by Iranian Tourism Investment Company. There is a large complex including hotel, pool and bathtub built next to the spring for therapeutic and recreational uses. Donbe, Soleimanie, Soda (Bakhtiary), Romatism and Hakim thermal springs are minor thermal springs and of less importance. Except for Hakim which has a temperature of 29.8°C, other minor springs have temperatures above 43°C. Due to the cold water of Hakim, this spring has received no attention and is left useless. For other minor springs and especially Soda, there are some facilities provided such as bathtubs and public pools. Thousands of tourists from all over the country and particularly from Markazi province, Qom, Kashan and Isfahan use these thermal springs annually. The springs are mostly used at spring and summer (August and September).

Water samples were collected and stored in 250 ml polyethylene bottles. Bottles were rinsed three times with the spring water before being filled. Each sample were collected and stored in 2 bottle: one of the bottles was acidified with Merck quality ultrapure nitric acid(HNO_3) for cations and trace elements and the other was kept unacidified for anion analysis. Unstable parameters(pH, T, Ec) were measured at the time of collection at the origin of each spring. For the remaining analysis, samples were collected and preserved in the field. Major ions(Na^+, K^+, Ca^{2+}, Mg^+, SO_4^{2-}, Cl^-, HCO_3^-, CO_3^{2-}) determined in the hydrochemical laboratory of Shiraz university. The determination were made within 48h after collection. Care was taken that the HCO_3^-, SO_4^{2-} and Ca^{2+} ions were analysed within 24h of sampling. Ca, Mg, Cl, CO_3^{2-}, HCO_3^- were analysed by titration. Na and K were measured using Perkin-Elmer flame-photometer and sulphate anion was measured by HACH turbidimeter. Trace element concentrations were determined by inductively coupled plasma-mass spectrometry(ICP-MS) at Amdel Group Laboratories, Australia.

RESULTS AND DISCUSSION

When it comes to treatment with mineral waters, it is water itself that plays the main role. Water can have healing, preventive and rehabilitation effects. In these kinds of treatments, water is used in different ways: it is possible to treat the patient through immersing in water (Balneotherapy); water can be the carrier for the solid components as well (Mudtherapy or Pelotherapy); it may also be drunk for certain purposes (Hydrotherapy). Among the foregoing ways of treatment balneotherapy and hydrotherapy are more common in Mahallat thermal springs, nevertheless hydrotherapy is less favorable in the sense that visitors usually do not know about it and simply exploit balneotherapy.

Balneotherapy in Mahallat thermal springs

Bathing and immersing in water are the main methods that are exploited by visitors in Mahallat thermal springs. It is thro-

Table 1. Chemical composition of Mahallat Thermal Springs.

Parameter	Shafa	Soleimanie	Romatism	Hakim	Donbe	Soda (Bakhtiari)
T(°C)	45.6	44.2	43.5	29.8	43.7	43.3
pH	6.6	6.55	6.64	6.85	6.58	6.7
TDS (mg/l)	2165	2147	2168	2305	2153	2208
SO_4 (mg/l)	1073.76	1038.72	1073.76	1100.16	1056.33	986.88
HCO_3 (mg/l)	195.2	201.3	225.7	183	237.9	219.6
NO_3 (mg/l)	0.35	0.173	0.165	0	0.15	2
NO_2 (mg/l)	0.050	0.012	0	0	0.193	0
Ca (mg/l)	374	420	384	390	376	388
Mg (mg/l)	38.4	19.2	37.2	75.6	48	49.2
K (mg/l)	1.95	1.95	1.95	2.34	1.95	1.95
Na (mg/l)	80.96	80.96	74.52	87.63	80.96	74.52
Fe (mg/l)	1.2	0	0	0	1.31	1.14
Al (mg/l)	0	0.48	0	0	0	0
Cr (mg/l)	0	0.13	0	0.02	0	0
S (mg/l)	458.8	466.5	461.2	491.8	464	465.5
Sr (mg/l)	7.2	8.39	7.03	7.85	7.05	7.18
Ba (mg/l)	0.02	0	0	0	0.02	0.02
Be (mg/l)	0	0	0	0	0	0
Si (mg/l)	40.46	-	-	-	-	-
F (mg/l)	2.5	-	-	-	-	-
Cl (mg/l)	60.35	63.9	56.8	63.9	53.25	60.35
Br (mg/l)	0	0	0	0	0	0
Mn (mg/l)	0.04	0.14	0.01	0	0.04	0.05
Pb (µg/l)	11	24	10	6	0	2
Sb (µg/l)	2.3	3.9	0.9	0.9	2.4	2.4
Zn (µg/l)	3.51	251.1	1.51	2.79	0.87	0.86
U (µg/l)	0.12	0.26	0.11	0.21	0.13	0.12
Cd (µg/l)	0	0.52	0	0	0	0
Se (µg/l)	0	1	0	0	0	0
As (µg/l)	19.2	13	5.49	5.68	21.4	18.5
Hg (µg/l)	2.26	2.13	2.47	3.36	1.81	2.6
Ag (µg/l)	0.46	0.24	0.81	0	0	0
Rb (µg/l)	14.7	24.2	14.8	15.7	14.8	15
B (µg/l)	470	560	240	170	140	130
Cu (µg/l)	1.61	33.1	0.39	0.67	0.4	0

Table 2. Chemical and physiological effects of Mahallat thermal springs.

Cation or Anion	Range		Healing Effects in Mahallat Thermal Springs	Consideration
	Max	Min		
Sodium	87.6 ppm in Hakim	74.5 ppm in Soda and Romatism	reduce rheumatism signs, healing nervous system diseases,improve postoperative disorders, and healing gynecological diseases.	Because the high temperature has an important role in treatment, the Hakim spring may have a less important role in treatment, though it has the highest concentration of sulfate.
Magnesium	75.6 ppm in Hakim	19.2 ppm in soleimanie	reduce the risk of heart diseases, prevent the development of psoriasis , help in buildings the bones and teeth, reducing the risk of incidence to cancer	
Potassium	2.34 ppm in Hakim	1.95 ppm in other springs	maintain normal blood pressure and prevent the development of psoriasis	
Zink	251 ppm in Soleimanie	0.8 ppm in Donbe and Soda	expedite the treatment and heal psoriasis	
Silica and fluorine	40.4 ppm for Silica and 2.5 ppm for florine	–	Silica increase the cardiovascular health and help to formation and remineralization of bones	only been measured in Shafa thermal spring, which is the biggest spring in the region
Arsenic	21.4 ppb in Donbe	5.5 ppb in Romatism	useful in treating venereal diseases and fungal infections, it is toxic and carcinogen	
Boron	560 ppb in Soleimanie	130 ppb in Soda	builds muscle mass, increase brain activity and strengthens bones	

ugh mechanical movements, heating, and chemical elements that balneotherapy imposes its effects on the human body.

Thermal and mechanical effects of Mahallat thermal springs

Except for Hakim spring the temperature of Mahallat Thermal Springs is between 43°C and 46°C so that they are categorized among hyperthermal waters (Albu et al. 1997). Shafa spring has the highest temperature whereas Hakim spring has the lowest (table 2). It seems that bathing in Mahallat thermal springs can help the patient in improving the heart and cardiovascular functioning.

Chemical and physiological effects of Mahallat thermal springs

The Chemical and physiological effects of Mahallat thermal springs are listed in table 1.

THE COMPARISON BETWEEN MAHALLAT THERMAL SPRINGS WITH SOME OF THE HEALING SPRINGS AROUND THE WORLD

Since all the thermal springs in Mahallat are of the same type, we have chosen Shafa spring, which is the biggest in the region, in order to make the comparison with the springs in the other parts of the world(Fig. 4 & Table 4).

La Roche-Posay spring in France has antioxidant characteristic since it contains copper, zinc, manganese and selenium elements (especially selenium); this spring can be useful in treating psoriasis and atopic dermatitis due to having anti-inflammatory effect (Karam 1996). In addition manganese may play a role in the effectiveness of balneotherapy for psoriasis (Halevy et al. 2001). It seems that among Mahallat thermal springs only Soleimanie can have antioxidant and anti-inflammatory effects, which is due to having above mentioned elements. In table 3 the chemical composition of La Roche-posay spring is compared with that of the Soleimanie and Shafa springs in Mahallat.

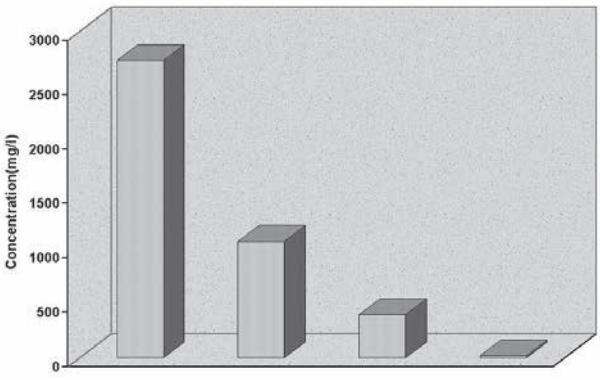


Figure 4. The comparison between the concentrations of sulfate of Shafa Spring with some healing spring in Greece. The Greek data are from Katsambas et al. 1996.

Therefore, it is possible that Mahallat thermal springs can also be useful, like the mentioned springs in treating eczema, psoriasis, some skin conditions such as atopic dermatitis, gout, digestive disorders, and rheumatism.

PHYSICAL AND CHEMICAL CHARACTERIZATION OF MAHALLAT THERMAL SPRINGS

The quality of thermal spring for therapeutic uses is determined based on their physical and chemical properties (Albu et al. 1997). According to the required properties for a healing water which are minTDS=1gr/l, having particular rare elements with known healing and physiological effects, etc., Mahalat Thermal Springs with TDS=2.147 (for Soleimanie) and TDS=2.305 (for Hakim) and also having elements and compounds such as Mn, Zn, Si, F, Rb, B, SO_4, HCO_3 and etc. are considered as healing springs. Mahallat springs are categorized as hyperthermal from thermal point of view and are considered as weak acidic based on its pH. According to another categorizing method which is based on the

Table 3. Comparison between Mahallat thermal springs with some of the healing springs around the world.

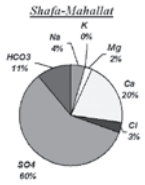
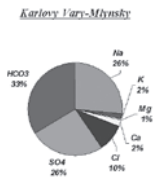
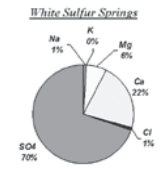
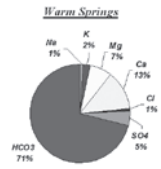
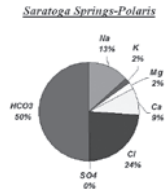
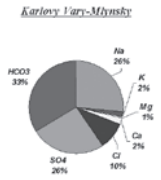
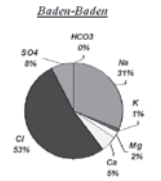
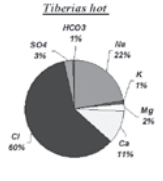
Shafa Thermal Spring 	Greece spas (Methana,...) Karlovy Vary springs (Czech Republic)	Sulfate waters	Healing Eczema, Psoriasis and atopic Dermatitis			
	White Sulfur Springs (USA)	Calcium Sulfate waters	Rheumatism and some skin conditions			
	Warm Springs (USA) Saratoga Springs(Polaris) (USA) Karlovy Vary springs (Czech Republic)	Bicarbonate waters	Treating digestive disorders, helpful in treating Gout			
	Baden-Baden (Germany) Tiberias (Dead Sea)	Sodium and Sulfate waters	Healing Rheumatism			

Table 4. The comparison of the composition of La Roche-Posay spring versus Shafa and Soleimanie springs. The La Roche-Posay data are from Karam 1996.

Spring	pH	T(°C)	HCO_3^-(ppm)	Ca (ppm)	Se (ppb)	Mg (ppm)	Sr (ppm)	Zn (ppb)	Cu (ppb)	Mn (ppm)
La Roche-Posay	6.96	13	396	140	0.06 ppb	4.9	0.26	0.022 ppm	0.005 ppm	-
Soleimanie	6.55	44.2	201.3	420	1	19.2	8.39	251.1	33.1	0.14
Shafa	6.6	45.6	195.2	374	0	38.4	7.2	3.51	1.61	0.04

chemical compounds and therapeutic properties, thermal springs are classified as bicarbonated, sulfated, sodium chlorinated and sulfurated waters (Skapare et al. 2003). Based on the results of analyzing the major anions and cations (table 2) as well as using piper and stiff diagrams and also concentration-ion diagram (fig. 5), all Mahallat Thermal Springs are categorized as calcium sulfated waters.

CONCLUSIONS

Mahallat Thermal Springs are capable of curing a wide range of diseases due to the fact that they contain a variety of components and elements. But this capability can't be perfectly judged until it is studied by physicians.

It is possible that many of the curing effects that were already mentioned could not be visible due to different reasons like the lack of enough components and useful elements for therapy. Some of the healing properties, which are related to the dominant compounds and elements of the springs, are evident and in fact, the fame of the springs is due to these kinds of properties.

Regarding the famous therapeutic properties of the springs (confirmed through ever increasing scientific evidences) and also comparing the springs' components with similar springs around the world one can prove or disapprove the therapeutic properties of the springs.

Mahallat Thermal Springs are well-known for healing skin diseases, rheumatism, gout, back pain, kidney stone, foot pain, atherosclerosis, sinusitis, discopathy and digestive disorders. Recent surveys on Mahallat Thermal Springs and comparison with other springs around the world have revealed that they have the capability of healing rheumatism, skin diseases, gout, kidney stone, and hypertensive nephritis and to some extent digestive and cardiovascular diseases. In addition, pain relief may also be observed as a result of using these springs.

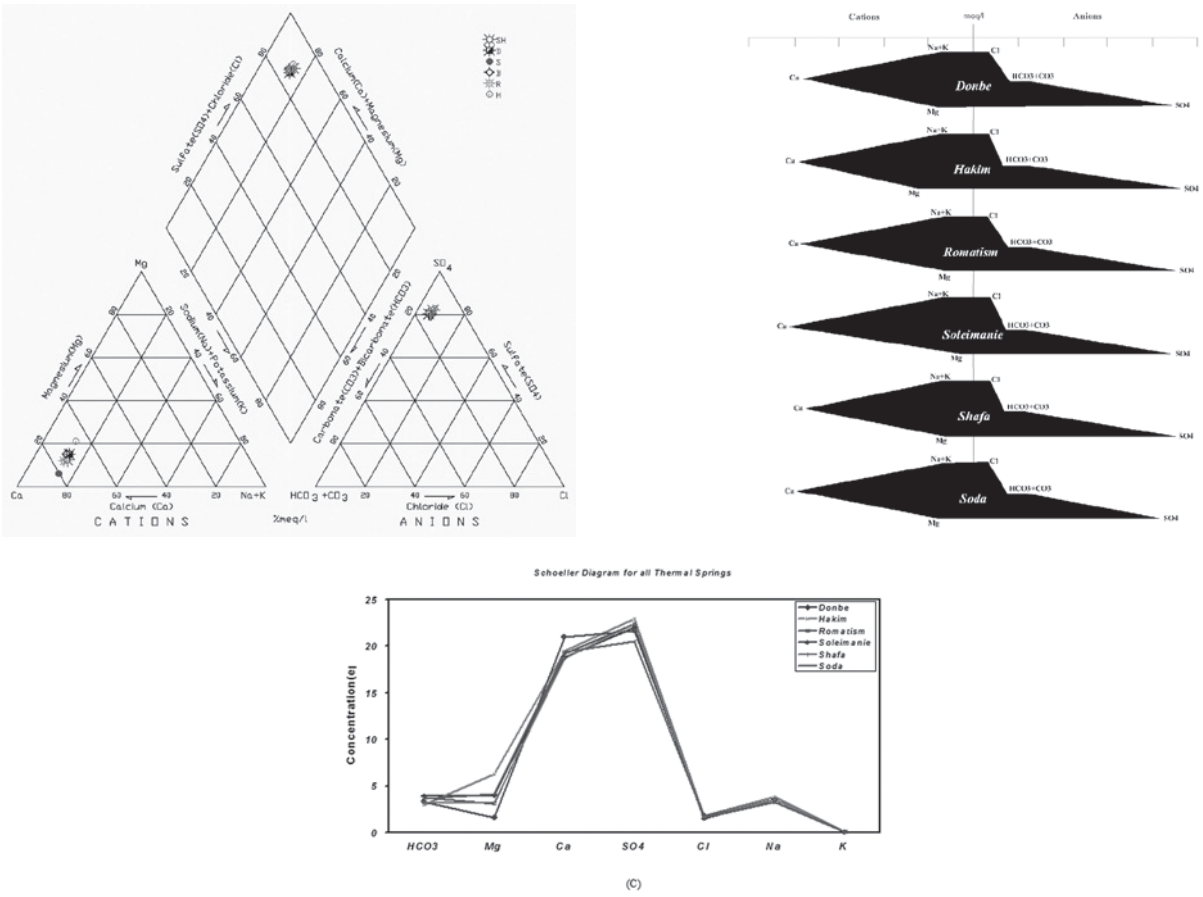


Figure 5. Piper diagram (A), Stiff diagram(B), and Ion-Concentration diagram © of Mahallat Thermal Springs.

Not only have been proven some of the well-known healing properties of the springs, but it is also possible that they can heal gynecological problems, nervous system disorders and venereal diseases.

Since there are numerous factors involved in healing process it is strongly recommended that future geomedicine studies will be carried out precisely covering every detail. As a result, the potential healing properties of Mahallat Thermal Springs may be used scientifically. It is evident that the results of these studies may play a major role in developing ecotourism in the region.

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ADDRESS FOR CORRESPONDENCE:
Vahid Moeini
Geology Department, Esfahan Paiam Noor University, Esfahan, Iran
e-mail: moeini57@yahoo.com