

Investigation of Physical and Chemical Quality of Hot Springs in South Khorasan, Iran

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Background & Aims of the Study: Many people use natural springs for many years to provide therapeutic, recreational, and in some cases, drinking water. The investigation of physicochemical properties and promotion of its indices in hot springs are very important for maintaining the health and well-being of individuals. The present study aimed to investigate some physicochemical properties of hot springs in South Khorasan, Iran, and compare them with the standards in 2018.

Materials and Methods: In order to assess the physicochemical quality of hot springs in South Khorasan, temperature, pH, electrical conductivity (EC), alkalinity, and total hardness parameters were measured and analyzed using standard methods. Data analysis was performed using Excel software (version 2010).

Results: Based on the obtained results, the highest temperature and EC were observed in Dig-e Rostam hot spring with 54.3°C and Ferdows hot spring with 10.43 µs/cm, respectively. Furthermore, the highest pH, alkalinity, and total hardness were obtained in Qaen hot spring with 7.87, Sarbisheh hot spring with 2018 mg/L CaCO₃, and Ferdows hot spring with 1204 mg/L CaCO₃, respectively.

Conclusion: Based on the results obtained from the review of the physicochemical quality of the hot springs in the southern Khorasan, most of the measured parameters of the springs were not within the standard range.

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Background

The use of natural spa fountains as a swimmer has been a human interest for a long time, and many people utilize spa fountains for therapeutic, healing, and recreational activities every year or in some cases. Nowadays, one of the most important uses of water in any region

area esthetic and recreational; accordingly, swimming is one of the recreational activities with a constructive effect on human physical and mental health(1). From a hygienic point of view, hot spring water, such as drinking water, should be physically, chemically, and ideally suited to the required standards to maintain the health and well-being of those who use them (2).

The physical and chemical factors in this

study include temperature, pH, electrical conductivity (EC), alkalinity, and total hardness. High water temperatures have a great effect on providing the opportunity for algae and germs to grow and affect the removal of swimmers' skin lesions (3). High water temperatures can cause swimmers to fall asleep, which can lead to the loss of consciousness, heat, or mortality. In addition, it can cause discomfort and hyperthermia for users (4, 5). High or low pH values can have many effects. If the pH value is low, it can corrode water pipes, eliminate chlorine, stain, and irritate swimmers' eyes and skin (6).

The EC of water reflects the ions present in the water because the ions conduct the electric current. Negative ions move to the positive pole, and positive ions move to the negative pole. Since this ability is a function related to the presence of ions in a solution, the measurement of EC is a good indicator for all solutes in water. The EC of pure water is very low, and as the concentration of ions increases, its electrical conductivity increases (7).

The alkalinity of water is considered one of the general properties of water. The acidity and alkalinity of water both depend on the amount of water-soluble carbon dioxide. Water hardness is a quality that results from the excessive soluble salts of calcium and magnesium, and to some extent manganese, aluminum, and zinc, making water consumption difficult in general and in the industry in particular. When rainwater passes through soft rocks, some minerals dissolve in water, resulting in the hardness of water.

In a 2012 study carried out by Naresh *et al.* on the physiochemical properties of hot springs in the Indian Ocean region, the results were compared with the World Health Organization parameters, and the water was good and edible (8). In a study conducted by Ghilamicael on the Physical and Chemical Characteristics of Five Hot Springs in Eritrea, it was shown that the water from the five Eritrean hot springs is

not fit for human consumption (9). In a study performed by Shito *et al.*, titled Physicochemical and Biological Analysis of Water Used for Drinking and Swimming in Nigeria in 2007, the results showed that the findings of the physicochemical tests were in accordance with the standards (10).

In a study conducted in 2012 on the physical and chemical properties and risk of community health in Ethiopian hot springs, it was demonstrated that water does not have a favorable physicochemical quality and may cause disease (11). In addition, the physical and chemical quality analysis of water samples taken from Meshkin Shahr spa pools by Movassagh *et al.* showed that none of them met the standards (12). In a study carried out by Hosseinzadeh *et al.* in 2014 on the investigation of the physicochemical and microbial indices of public swimming pools in Boroujerd, Iran, it was observed that in all the studied pools, the health indices were in good levels. However, in some cases, physicochemical parameters were within the standard range. do not exist and require constant monitoring (13).

Aims of the study

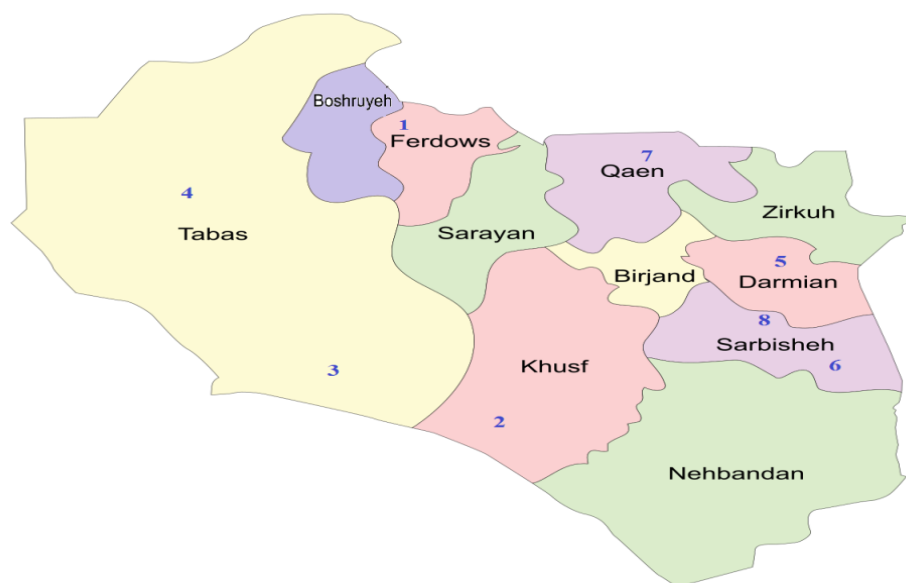
The purpose of this study was to evaluate the physicochemical quality of natural active hot springs in South Khorasan, Iran, for the health and drinking and compare them with the standards in summer and autumn. South Khorasan has a number of hot springs whose physicochemical characteristics are not documented. The present study was carried out for 6 months in two stages in 2018. Field data and water samples were collected from eight hot springs, namely Ferdows, Lot, Dig-e Rostam, Tabas, Darmian, Sarbisheh, Qaen, and Abtorsh.

Materials & Methods

This experimental study was performed on

Table 1) Geographical coordinates of South Khorasan natural spa springs

Number	Hot spring	Longitude	Latitude
1	Ferdows	85.213871	34.138788
2	Lot	58.319401	32.46909
3	Dig-e Rostam	57.515057	32.277444
4	Tabas	57.1639	33.662718
5	Darmian	60.26137	32.89848
6	Sarbisheh	59.985648	32.565161
7	Qaen	59.699404	32.891218
8	Abtorsh	59.80489	32.772983

**Figure 1) Analyzed samples in this study collected from eight hot springs in South Khorasan, Iran**

eight natural active hot springs in South Khorasan in 2018. This study was approved by the Ethics Committee of Birjand University of Medical Sciences in Birjand, Iran, with the ethics code of 2018.126.IR.BUMS.REC. South Khorasan is one of the eastern provinces of Iran with numerous mineral springs that have multiple healing properties. The Active hot springs with their geographical coordinates, are listed and shown in Table 1 and Figure 1, respectively.

Given that most tourists visit the hot springs in summer and autumn, the analysis of the physicochemical quality of natural spa springs was conducted in one stage in summer and another in autumn. At each stage, four samples were obtained from the water intake at midday according to sampling conditions. In addition,

temperature and pH parameters were measured using a pH meter (WTW, Germany) and an EC gauge portable (Knick model, Germany). To measure the total hardness and alkalinity of the specimens with the titration method, the specimens were transferred to Birjand University of Medical Sciences Laboratory under the standard conditions, and the measurements of each sample were repeated three times according to a standard method (14, 15). The total hardness and alkalinity of water were calculated by titration in the laboratory. Then, the results were analyzed using Excel software (version 2010).

Alkalinity Testing

Alkalinity is significant in many uses and treatments of natural waters and wastewaters.

As the alkalinity of lots of surface water is composed of carbonates, bicarbonate, and hydroxide, it is also assumed to be an indicator of these constituents. Alkalinity in the excess of alkaline earth metal concentrations is significant in the determination of the suitability of water for irrigation. Regarding the titration of the sample size and normality of titrant, 0.02N or 0.1N sulfuric (H_2SO_4) was used for the standard alkali of that method. Then, formula 1 was used to calculate alkalinity (15).

$$\text{Formula 1: Alkalinity (mg/L CaCO}_3\text{)} = \frac{A \times N \times 50000}{mL_{\text{sample}}}$$

A: used mL standard acid

N: normality of standard acid

ML: milligram sample

Total Hardness Testing

For the determination of total hardness, the titration method with ethylenediamine tetraacetic acid (EDTA) solution was used as in formula 2.

$$\text{Formula 2: Total hardness (mg/L CaCO}_3\text{)} = \frac{A \times N_{\text{EDTA}} \times 100000}{V_{\text{sample}}}$$

A: used mL EDTA

N: normality of EDTA

Results

The average results of physicochemical properties of water from the natural hot springs of South Khorasan, including temperature ($^{\circ}C$), pH, EC ($\mu S/cm$), total hardness, and alkalinity ($mg/LCaCO_3$), are presented in Table 2. In all hot springs, water flows from one side to the other and does not rotate.

According to the results of this study regarding the temperature of natural hot springs in South Khorasan, Dig-e Rostam and Sarbisheh hot springs had the maximum and minimum temperatures measured as 54.3 and

17.1 $^{\circ}C$, respectively. In addition, the highest and lowest pH values of spa springs in South Khorasan were obtained for springs in Darmian and Lot. Based on the EC results of South Khorasan spa springs, Ferdows and Darmian spa springs had the highest and lowest EC values, respectively.

Discussion

In Iran and developing countries in recent years, the pollution of water resources has increased with increasing population growth and industrial activities. On the other hand, the need for better water quality has increased. Therefore, for the protection and sustainability of human and community health, the water available to the consumer should comply with national and international standards. There is no specific physicochemical standard for natural spa springs; consequently, the physical and chemical quality of these springs was compared to that reported for the swimming pools.

In the present study, according to Table 2 (1), Dig-e Rostam and Abtorsh hot springs had the maximum and minimum temperatures measured as 54.3 and 17.1 $^{\circ}C$, respectively. As the standard temperature for swimming pools is 29 $^{\circ}C$ (16), the temperature of the hot springs in South Khorasan was not within the standard temperature range. Moreover, most hot springs had lower temperatures than the standard temperature, and the rest of the springs had temperatures higher than the standard range. It should be noted that the extremely high temperature at Dig-e Rostam springs has created problems for some users due to local evidence.

In Canada, the optimum standard temperature for hot springs is proposed within the range of 38-36 $^{\circ}C$ (17). In assessing the temperature of the swimming pools in Hamadan, Iran, only 40% of the samples were out of the standard range, and the rest were

Table 2) Mean values of water sample of South Khorasan hot springs in terms of temperature (°C), pH, electrical conductivity($\mu\text{S}/\text{cm}$), total alkalinity ($\text{mg}/\text{L CaCO}_3$), and hardness($\text{mg}/\text{L CaCO}_3$)

Hot spring	Temperature	pH	Electrical conductivity	Alkalinity	Hardness
Ferdows	34 \pm 0.8	6.65 \pm 0.0	10.34 \pm 0.8	202 \pm 35	1204 \pm 46
Lot	42 \pm 1.2	6.47 \pm 0.0	8.87 \pm 0.8	282 \pm 42	860 \pm 32
Dig-e Rostam	54.3 \pm 1.7	6.95 \pm 0.4	4.66 \pm 0.6	216 \pm 22	660 \pm 28
Tabas	33.7 \pm 0.9	6.87 \pm 0.0	1.77 \pm 0.2	144 \pm 17	268 \pm 18
Darmian	32.5 \pm 0.6	7.79 \pm 0.2	1.23 \pm 0.2	165 \pm 20	192 \pm 12
Sarbisheh	33.5 \pm 0.4	6.87 \pm 0.0	6.92 \pm 0.5	2199 \pm 55	432 \pm 24
Qaen	35.8 \pm 0.7	7.87 \pm 0.2	1.43 \pm 0.1	166 \pm 12	140 \pm 10
Abtorsh	17.1 \pm 1.1	6.89 \pm 0.1	1.8 \pm 0.2	807 \pm 28	688 \pm 28
Swimming pool standard	26-28	7.2-8	No guideline	\leq 150	\leq 200-300

within the standard range (18). In addition, in a study conducted in Jordan, most swimming pools were in poor condition, such as hot springs in South Khorasan, with higher temperatures than the standard conditions (19).

High pH values reduce chlorine efficiency so that at pH above 8, only 20% of chlorine is hypochlorous acid, which is an effective disinfectant. High or low pH values can have many effects. A low pH value can cause the corrosion of water supply pipes and filtration systems, loss of chlorine, staining, and irritation of swimmers' skin in pools, and if pH value is high, it may cause particles to sediment on the floors and walls of swimming pools, water pipes, and sand filtration systems (20). In the present study, the pH values in Qaen and Lot hot springs were the highest, reported as 7.87 and 6.47, respectively, according to the pH standard of the swimming pools, documented as 7.2 to 8 (6).

Only the pH values of Darmian and Qaen hot springs were within the standard range. In comparing the pH values of South Khorasan hot springs with those of Ayob North (13), Kerman (16), Gorgan (21), Isfahan (22), and Shahrekord (23) hot springs, most of them were within the standard pH range. However, the pH value of hot springs in Nir, Iran, (17) similar to those in South Khorasan, was not within the standard range. According to Table 2, the highest and lowest EC values of Ferdows spa were 10.34 and 1.23 $\mu\text{S}/\text{cm}$, respectively.

In terms of alkalinity, according to Table 2, the maximum and minimum alkalinity reported for Sarbisheh and Tabas hot water springs were 2199 and 144 ($\text{mg}/\text{L CaCO}_3$), respectively. The alkalinity of all hot water springs was within the standard range of $150 \geq$ (12), except for Tabas hot spring. The effluent of most hot springs is used for agricultural and other purposes; nevertheless, the high alkalinity in the hot springs of Sarbisheh has caused water to run into the environment after leaving the pool, and no use can be made. Therefore, there were no bushes, plants, and vegetations around.

On the other hand, local evidence and users suggest that healing wounds and joints, as well as rheumatic pain, were among the benefits of using the spa. As stated in the scientific literature, the high levels of alkali can cause problems, such as water turbidity, hard pH adjustment, and elevated pH. According to Table 2, in most cases, the level of alkalinity is higher than the standard level. In addition, in some cases, the total hardness is excessive, which can cause problems, such as sedimentation and cloudy state, in the pool water (16, 24).

With the consideration of the hardness, water can be divided into four categories, namely soft (less than 75 $\text{mg}/\text{L CaCO}_3$), medium (75-150 $\text{mg}/\text{L CaCO}_3$), hard (150-300 $\text{mg}/\text{L CaCO}_3$), and very hard (higher than 300 $\text{mg}/\text{L CaCO}_3$) (25). The incidence of kidney disease, hypertension, esophageal cancer, stomach, sudden deaths,

Table 3) Comparison of compliance percentage of each parameter measured according to the standards in South Khorasan spa springs with those of some springs and swimming pools

Parameter	Standard rate	South Khorasan	Meshkin Shahr	Urmia	Boroujerd	Khorramabad
Temperature (°C)	26-28	0%	0%	76.2%	54.16%	18%
pH	7.2-8	28%	0%	83.85%	100%	83%
Alkalinity (mg/L CaCO ₃)	≤150	12.5%	0%	69.1%	12.5%	23%
Total hardness (mg/L CaCO ₃)	≤200-300	37.5%	0%	72.91%	37.5%	3.3%

kidney stones and bladder increase when water hardness increases (26).

According to the results in Table 2, the maximum and minimum hardness reported for Ferdows and Ghayen hot water springs were 1204 and 144 (mg/L CaCO₃), respectively. Regarding the hardness of hot water springs, only Tabas hot spring was within the standard range (≤200-300) (12). According to Table 3, regarding the comparison of the values of each measured parameter, the physicochemical quality of hot springs in South Khorasan in comparison to the standard level was reported with better quality than Meshkin Shahr (12) hot springs, and swimming pools in Urmia (6), Boroujerd (13) and Khorramabad (27) are of lower quality. Since according to the results, most of the measured parameters of the physicochemical quality of hot springs in South Khorasan were not within the specified standards, it may be hazardous to use some springs or their drinking water.

Conclusion

According to the findings of the present study, none of the hot spring parameters were within the standard range based on the physicochemical evaluation of the hot springs. On the other hand, the high temperatures of some sources, such as Dig-e Rostam, may pose risks for the users. In addition, only spa springs in Darmian and Qaen in terms of pH, only spa springs in Tabas regarding alkalinity, and only spa springs in Qaen, Darmian, and Tabas considering total hardness, were within the

standard range. The rest of the spa springs' parameters were not in the standard range. If they are used for drinking, it may cause disease. It is also recommended to set standards for natural hot springs without damaging their natural and therapeutic properties.

Footnotes

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Conflict of Interest

The authors declare that there is no conflict of interest.

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