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ORIGINAL ARTICLE

Presenting a Risk Management Model for Mineral Hot Spas Based on the Qualitative Index: A Case Study in Ardabil City, Iran

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ABSTRACT

Regarding significant number of the people affecting by factors, such as gas poisoning, microbial, and heat exhaustion in mineral hot spas, the present study was conducted aimed at providing a model for measuring and managing the risk of using hot mineral spas. In this research, a conceptual model of risk was prepared in four stages. Firstly, 16 qualitative parameters were extracted, their effect weight of which was obtained based on the amount of risk for users was determined by fuzzy analysis method. According to the amount and standard range allowed for each parameter, quantitative and qualitative risk categories were obtained in five ranges for each parameter based on the obtained weights and opinions of the health experts. Then, the final result regarding risk of using each spa was obtained by combining these parameters. For assessing risk of using hot mineral spas in Ardabil province by the method invented in this research, at first, water samples were collected from six spas in different parts of Ardabil province. Then, risk management of six spas was evaluated. According to the results, the Qotursuyi spa had a high level of risk, the spas of Shabil, Gavmishgoli, and Qinarjeh had a moderate level of risk. Under responsible risk management, natural hot springs present a renewable resource for sustainable tourism development on a long-term basis.

KEYWORDS: *Balneotherapy, Qualitative Index, Risk Management, Spa*

INTRODUCTION

Given high abundance of hot springs, tourism industry in the area is developing industries in Ardabil province (northwestern of Iran). The lack of a comprehensive standard and appropriate measure to eliminate the dangers of gas poisoning from dangerous gases emitted in mineral spas and removal of microbial contaminants without using per chlorine known as a barrier in evolving this industry. It causes several death annually in various hot spas in Ardabil province [1-2]. Therefore, these issues might negatively impact the reputation of the most important tourist attractions due to the possibility for spread of bad news regarding death of the people in hot springs at the national and international levels [3]. In addition to the global average, the statistics related to the accidents caused by the emitted gases in mineral hot spas of Ardabil province are much higher than the national average [4], indicating the need to develop preventive programs.

Mineral hot springs cannot be managed by the standards and requirements of ordinary spas (approved by the Standards Organization, Ministry of Health, and Ministry of Labor) due to certain factors, such as hazardous gases and high temperatures [5]. For example, microbial disinfection of these waters cannot be done using per chlorine because; the substance reacts with specific compounds in mineral waters and undergoes another process [6]. Microbial contamination is also evident according to the studies conducted in these waters. In addition, there is the possibility of occurrence and intensification of pulmonary complications by per chlorine vapors due to exposure to hazardous gases emitting from the water bed, making the traditional method (chlorination) unusable. Due to the lack of comprehensive national standards for hot mineral spas, similar standards used for ordinary spas are used for these kinds of spas [7-8].

According to the provisions of National Standard No. 20483 (on how to use hydrotherapy centers and hot springs) [9], activities of diving and professional swimming cannot be performed by all the people. Also, the National Standard No. 15572 [10], (which is also the translation of the International Standard No. ISO 17679) first of all, declares providing qualified welfare and treatment services to customers and generalizes about the issue of ensuring health of the people and only suffices about hot water temperature and how to adjust the temperature through ventilation and in the National Standards No. 11202 (regarding spas) [11], as well as the current regulations and requirements of the Ministry of Health and the Ministry of Labor, only the requirements of public safety and public health are explained in general [12]. Accordingly, the main purpose of the present study is to provide a conceptual model of risk management based on the water quality indicators to measure the healthy use of spa.

In the previous studies, there were dangers of using mineral hot spas. In a study conducted in Spanish hot mineral waters, the role of microbial components in water of natural mineral spas was investigated to determine the effect of physical factors on microbial components in mineral waters. It was concluded that the temperature of mineral spas had a positive effect on bacterial growth [13].

In another study on more than 27,000 mineral spas in Japan, conducted by traditional health practitioner, it was found that hot spas as a therapeutic landscape play an important role in maintaining health and well-being of the Japanese people. It is of particular importance to update hot spas standards to enjoy the advantages of these facilities for social improvement and cultural development. Therefore, further studies would be recommended to study management improvement and health status [14].

In a study, microbial and physicochemical quality of mineral spa water in Sarein city were assessed with emphasis on S. aureus bacterium as one of the organisms involved in skin and eye infections in the first half of 2011. In this study, 85 mixed samples of mineral spas in Sarein were taken from May to September during the peak time for presence of the swimmers.

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Residual free chlorine, temperature, pH, turbidity, H_2S (hydrogen sulfide), oxidation-reduction potential (ORP), dissolved oxygen (DO), and electrical conductivity [15] were measured at the sampling site by portable devices. The results showed that 53.3% of the samples in terms of total coliforms, 9.41% of the samples in terms of fecal coliforms, 84.71% of the samples in terms of heterotrophic plate count (HPC), and 81.18% of the samples in terms of S. aureus had excessive contamination, which is a warning sign regarding occurrence of skin diseases and possible infections for swimmers [8].

In another study, quantity and quality of hot spas were studied in Iran and it was found that most of these springs do not have good health and welfare conditions. Thus, it was concluded that if proper conditions and basic facilities are provided and upgraded, Iran would be introduced as a worldwide hub of natural tourism and therapy [16].

Isinuka springs in South Africa are traditional spas used by hundreds of people every day. In a study on its physical and chemical properties, it was found that clay sediments of the cave and swimming spa water had a high concentration of calcium (with the maximum level of 134506 mg / kg), a rare metal of iron (up to 36272 mg / kg), and toxic metal of lead (up to 25 mg / kg). Levels of basic and toxic metals except zinc and copper were reported to be high in water. The level of aluminum, a metal with antibacterial activity in pond sediments was measured as 71,792 mg / kg [17].

In another study, a quantitative microbial risk assessment (QMRA) model was evaluated for Legionnaires' disease (LD). Parameters including prevalence of aerosol particles, water composition, duration of exposure to disease, and building ventilation were estimated by a two-part climate model. This assessment was considered in two spa complexes, regarding transfer of Legionella from the water phase to air particles in the spa. This model was able to estimate colony concentration of the disease agent in spa air. However, estimates about disease exposure were not reasonably accurate, and it was concluded that further research is needed to improve the data used to assess exposure to Legionella germs [18].

In a study, a safe and standard disinfection strategy was evaluated in spas. Antimicrobial activity was assessed in the water of four different spas with high mineral content and water of a drinking spring with low mineral content. Antibacterial activity of titanium dioxide (TiO_2) nanomaterials and exposure to light at different wavelengths (635-200 nm) were evaluated. It was found that antibacterial activity was decreased by 75-80 colony-forming unit (CFU) in all waters with high mineral content. Antibacterial activity of TiO_2 showed an additional effect with a decrease of more than 99% within 2-5 hours [6].

Based on the conducted studies and considering incompleteness of the provisions of standards No. 15572 and 20483 (regarding the use of hydrotherapy centers and hot spas) for safe use of hot water on the one hand. A quantitative and qualitative development of mineral hot spas on the other hand, there is a need to define a comprehensive procedure for safe and healthy use of mineral spas in order to boost the tourism industry and the region's economy. A comprehensive research recommendations made by Erfurt in their doctoral dissertation was also conducted as a meta-analysis in mineral spas of most countries [19], and also results of a study on providing a QMRA model [18] showed importance of providing a QMRA model for mineral spas.

Therefore, this research was carried out to present a new concept and solution in the field of presenting a conceptual model based on physical, chemical, and microbial components to deal with various environmental conditions including the emitted gases and other dangerous factors in Ardabil province's hot springs.

MATERIALS AND METHODS

In this research, a conceptual model of risk management was prepared in four stages based on the principles of ISO 31000 risk management standard, including planning, identifying, evaluating, monitoring, and reporting solutions [20]. So that, in the planning stage, it is determined how to manage potential risks and the general framework of the model is specified to show the risk of using mineral spas. The second stage was to identify the parameters of potential risks that may exist in various forms, such as qualitative parameters and environmental conditions. The third stage was to evaluate the identified risks using the criteria of qualitative parameters and requirements of the current standards, etc. Thus, risks were evaluated based on their probability of occurrence and possible consequences. Given this risk management model, and based on the parameters of the qualitative index of hot mineral spas, these criteria were divided into five categories, including no risk, bearable partial risk, moderate risk, high risk, and unbearable risk. In the fourth stage of risk management process, the risk was managed in four ways, including reducing and eliminating, avoiding, assigning, and accepting risk. Therefore, it can be called as solution presentation stage. In the last stage, monitoring and reporting were feedback of the solutions, and for each spa, conditions and level of the risk were determined. Finally, the management measures were determined by providing the solution and monitoring performance.

This method is a systematic process in identifying the results of the main analytical techniques and to determine the main causes of the accident.

A large number of accidents in the spas were related to poisoning with gases emitted from hot mineral spas. Therefore, it was attempted to analyze record of the accidents in hot springs of the province to determine share of accidents caused by gas poisoning among other factors. Then, all the available national and international scientific, research documents, and reports [21] regarding the risk models for the use of mineral hot spas were used. We also identified and selected qualitative components of research on contents and requirements of the current standards and the results of analyzing the accidents of hot mineral spas by root cause analysis (RCA).

Having identified and determined parameters of the qualitative index, by extracting from national and international standards as well as spa incident file's, structure and categories were considered for each of the components. The components were considered based on the determined parameters of the qualitative index. Then, the fuzzy hierarchical analysis method was used in weighing and determining their level to analyze these components. Finally, the model output was determined conditions for using mineral spas (fourth and fifth stages of ISO standard 31000).

The current study was conducted in mineral spas of Ardabil province, as shown in Figure 1. Water quality factors of spas in several cities of the province, including Nir, Sarein, and Meshkinshahr were measured by the certified company after sampling at the times with moderate visits.

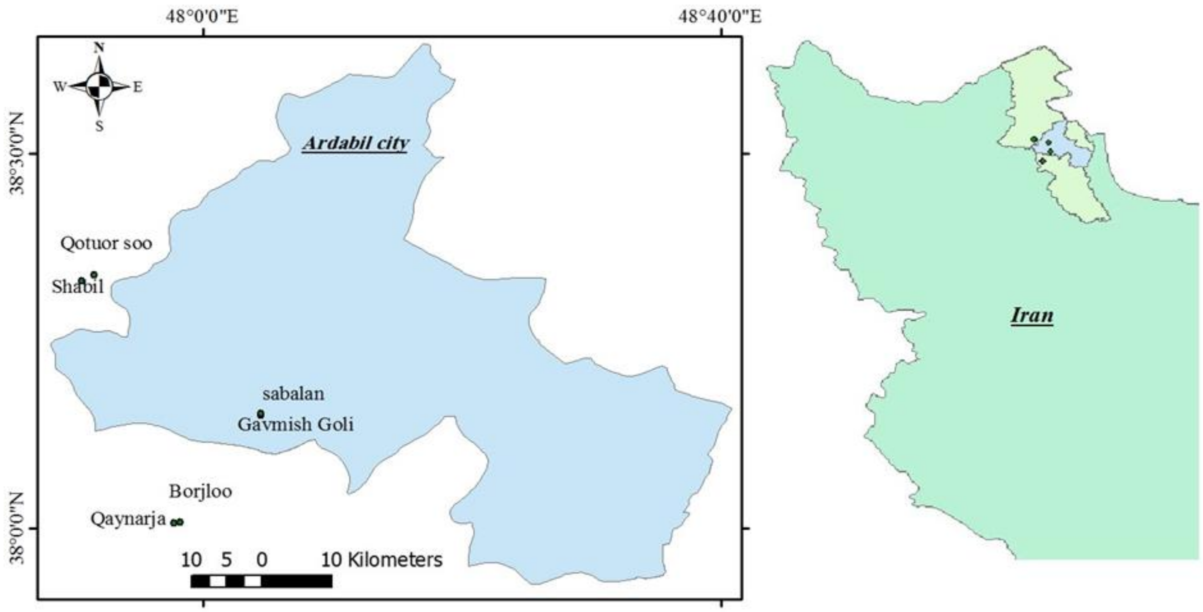

Figure 1. Location of six spa centers studied in Ardabil

Setting of this research was mineral spas of Ardabil province, as shown in Fig. 1. Water quality factors of spas in several cities of the province including Nir, Sarein, and Meshkinshahr were measured by the certified company after sampling at the times with moderate visits.

The qualitative factors used in this method were classified in three main categories, including chemical, physical, and microbial and 16 subgroups (see Table 1). The measured qualitative factors included physical components like water temperature, air temperature, pH total dissolved solids (TDS). Chemical components, including gas phase, CO_2, H_2 S, SO_2 , NH_3 in liquid moderate, parameters of H_2 S, Ca, Mg, HCO_3, F. Microbial components, including coliforms, Escherichia coli, and number of colonies. Flowchart of the modeling method in the current research has been presented in Figure 2.

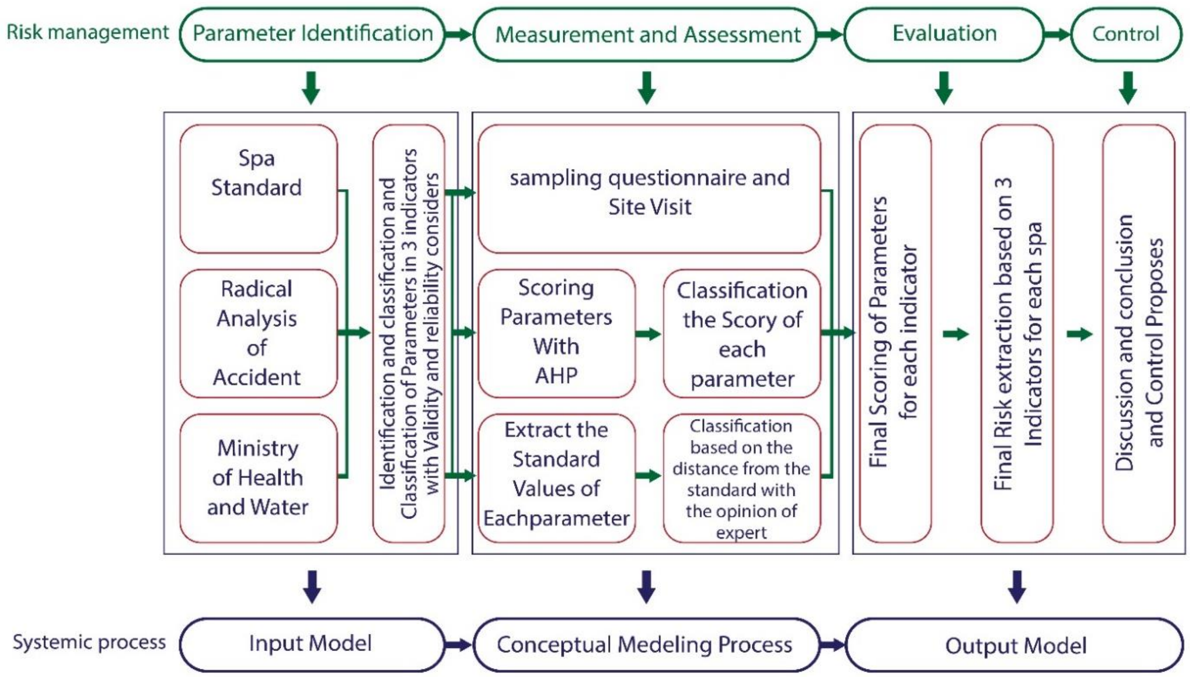

Figure 2. Flowchart of the risk management model steps.

First, the qualitative data were arranged as an input to the conceptual model. In the next step, the results of accident analysis, statistical tests, and fuzzy weighting using a questionnaire regarding the current standards of hot mineral spas were determined. Then, based on the quantitative amounts in data analysis section, each of the components and the amount of weight assigned to the categories were considered for them. Finally, safety and health category of the mineral spas were obtained by determining their level of risk based on the quantitative and qualitative categories of the considered parameters and scoring of these categories. The process of these steps has been presented in Figure 3.

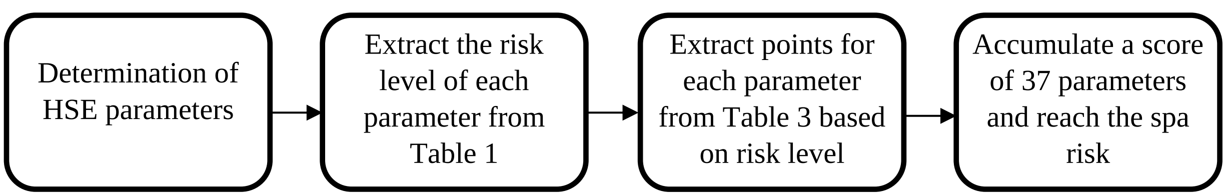

Figure 3. Steps of identification-measurement of parameters and analysis-scoring in the risk model.

In this method of risk management, a total of 16 factors were scored with a total number of 100 points. The score of each factor was obtained through a questionnaire with a separate table, involving micro-factors with technical details. Finally, a risk number was calculated for each spa. In this method, five categories of risk management, including no risk, low risk (bearable), moderate risk, high risk ,and unbearable risk were considered for spas. Its quantitative score was obtained by 25 points according to Table 2. Five levels were considered for each parameter. If the parameter value was within the standard value range, the level had no risk and the other 4 risk levels were applied according to the classification mentioned in the above section. According to Table 1, for each parameter, based on the standard amount and risk ranges obtained by opinions of the health experts, five categories were considered based on the five categories of the obtained risk model. For each parameter obtained from the laboratory results, its risk level was specified in Table 1 and Table 3. Risk level score of the parameter was determined in Table 5.

Table 1. Attributions of 5 risk levels for Quality parameters Based on standard values.

Unbearable Risk (5)	**High Risk (4)**	**Moderate Risk (3)**	**Acceptable Risk (2)**	**No risk (1)**	**Standard limits (Unit)**	**Parameter**	
≥4	3.1-4	2.1-3	1-2	1≥	1≥	**Water dissolved H2S**	**Chemical**
≥3	2.1-3	1.1-2	0.1-1	٠	٠	**Air H2S**	
150 ppb/h≥	**130 ppb/h**	**110 ppb/h**	**90 ppb/h**	***75 ppb/h**	**75 ppb/h[1]**	**Air SO2**	
3>	2.1-3	1.1-2	0.1-1	0	0	**Air NH3**	
500>	451-500	401-450	351-400	≥350	350	**Air CO2**	
800>	701-800	601-700	501-600	≥500	500	**Ca**	
300>	251-300	201-250	151-200	≥150	150	**Mg**	
1900>	1701-1900	1501-1700	1301-1500	≥1300	1300	**HCO3**	
4>	3.1-4	2.1-3	1.1-2	≥1	1	**F**	
60> <5	57-60 5-10	55-57 10-15	15-55	≥45	15-55	**Water temperature**	**Physical**
Tw±15	**Tw±13**	**Tw±11**	**Tw±9**	**Tw±7**	**Tw±5**	**Air temperature**	
1100>	1001-1100	901-1000	801-900	≥800	800>	**TDS**	
9.5> <5.5	9.1-9.5 5.5-6	8.6-9 6-6.5	8.1-8.5 6.5-7	7-8	7-8	**Ph**	
4>	4	3	2	≥1	1	**TCF [2]**	**Microbial**
4>	4	3	2	≥1	1	**FCF [3]**	
350>	301-350	251-300	201-250	≥200	200>	**HPC [4]**	

[1]: a daily maximum 1-hour concentration approx. 75 ppb, [2]: Total Coliform Count, [3]: Fecal Coliform Count, [4] : heterotrophic Count

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Table 2. Qualitative category after total ranking values of 16 factors in the risk management model.

Risk Class (Qualitative category)	Weighting Score
No risk	**0**
Acceptable Risk	**1-25**
Moderate Risk	**26-50**
High Risk	**51-75**
Unbearable risk	**76-100**

RESULTS

Qualitative parameters were measured based on the experts' opinions in the form of a questionnaire. Then, these parameters were divided into three categories, including chemical with a total score of 57, physical with a total score of 16, and microbial with a total score of 27. According to Table 3, the highest weight was allocated to the dissolved and volatile H_2 S with a score of 16 for each in the section of chemical parameters, and the lowest score was related to the total suspended solids in water as a parameter of the physical parameters with a value of 1. Figure 4 shows output of the fuzzy hierarchical analysis method for weighting 16 parameters of this research.

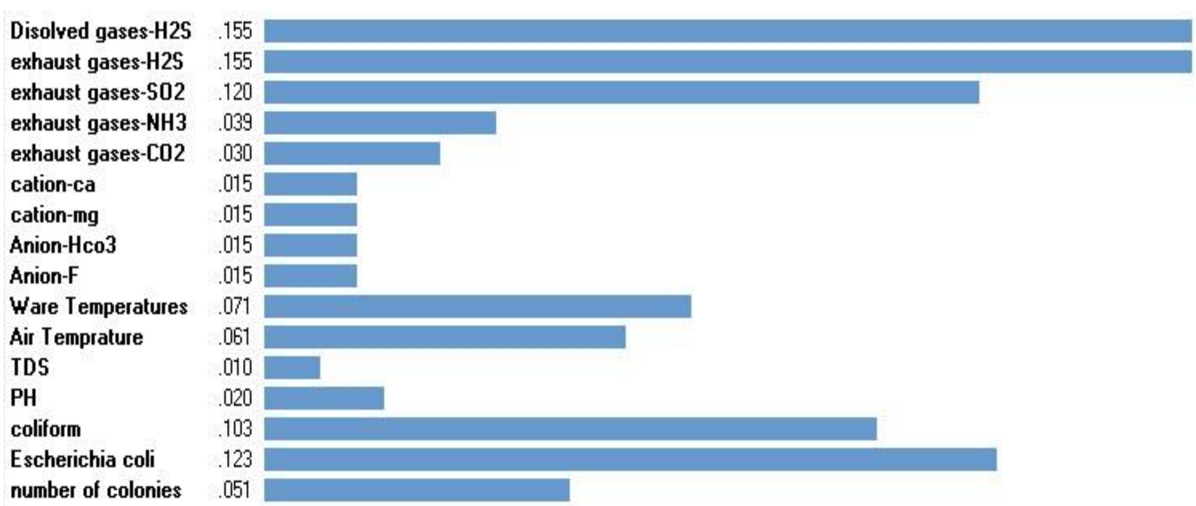

Figure 4. Weighting scores of 16 quality parameters by fuzzy hierarchical analysis.

Based on the opinions of the experts in the field of accidents and forensic reports and regarding autopsy of the deceased in hot mineral spas, it was found that sulfur compounds (H_2S and SO_2) were the main causes of suffocation and death. According to other forensic evidence, sulfur compounds, in addition to a direct effect on human suffocation, also cause lethargy by dropping blood pressure, resulting in falling of a person into the water and indirectly causing suffocation caused by water. Other studies have emphasized these parameters as well [17]. After chemical parameters, microbial factors, such as Escherichia coli and coliforms were identified as effective parameters in health threats as well as risk management model in this study. After these parameters, the two factors of water temperature and ambient air temperature around these spas were ranked as influential factors in the risk management model in this study, which can also intensify the effect of chemical parameters. This secondary effect is shown in Fig. 5. According to the initial study, it was found that sulfur gases also had an effect on microbial parameters, as presented in Fig. 6. Other parameters of the chemical and physical indicators showed less effect.

The score range of each parameters' weighting were obtained into four equal parts as shown in Table 3. Some parameters were rounded off to simplify the score. In this management model, risk was classified into five categories, and if the value of a parameter was equal or less than its standard value, it was in category 1 or without risk, which was zero. These five risk levels were prepared according to the increase in the standard value (see Table 1). The spa water samples get a corresponding score from Table 3 if they were in any level presented in Table 1.

Table 3. Weighting scores of Quality parameters in 5 risk classes.

Risk range rating					Weighting Score	Parameter	
Unbearable (5)	**High (4)**	**Moderate (3)**	**Acceptable (2)**	**No risk (1)**			
16	12	8	4	0	16	**Water H2S**	**Chemical**
16	12	8	4	0	**16**	**Air H2S**	
12	9	6	3	0	12	**Air SO2**	
4	3	2	1	0	**4**	**Air NH3**	
3	2.25	1.5	0.75	0	3	**Air CO2**	
1.5	1.125	0.75	0.375	0	1.5	**Ca**	
1.5	1.125	0.75	0.375	0	1.5	**Mg**	
1.5	1.125	0.75	0.375	0	1.5	**HCO3**	
1.5	1.125	0.75	0.375	0	1.5	**F**	
7	5.25	3.5	1.75	0	**7**	**Water temperature**	**Physical**
6	4.5	3	1.5	0	6	**Air temperature**	
1	0.75	0.5	0.25	0	1	**TDS**	
2	1.5	1	0.5	0	2	**Ph**	
10	7.5	5	2.5	0	10	**TCF**	**Environmental**
12	9	6	3	0	**12**	**FCF**	
5	3.75	2.5	1.25	0	**5**	**HPC**	

The results of measurements and samples of six hot mineral spas were analyzed and 16 parameters were obtained for each sample (refer to Table 4). The results of Table 4 showed that QoturSuyi spa had the highest values of chemical parameters and Sabalan spa had the lowest values of chemical parameters. In the case of the emitted gases, the hot springs of QoturSuyi and Shabil had multiple amounts compared to other spas and their temperature were higher due to the increase in the amount of these gases. QoturSuyi and Busheli spas had the highest and lowest values with respect to physical parameters, respectively. Due to the fact that microbial parameters were influenced by sulfur-emitting gases, Gavmish Goli and Busheli spas had the maximum and the minimum ranks, respectively.

Table 4. Chemical, physical, and microbial characteristics of the natural spas in the present study and their standard values.

Borjloo	Qaynarja	Sabalan	Gavmishgoli	Shabil	Qotur Suyi	Standard	Unit	Parameter	
38.2	58.4	33.4	48.1	31.1	52.1	15-55	◦C	**Water Temp**	**Physical**
35	34	33	32	30	34	Tw±5	◦C	**Air Temp**	
6.8	7.6	6.1	6.2	6.5	3.1	7.8	-	**PH**	
3231	1095	2123	1042	6054	1121	800>	mg/lit	**TDS**	
1.7	1.7	0.9	1.7	32	98.5	0	mg/lit	**Air H2S**	**Chemical**
0	0	1	0.5	58	68	0.075	ppm/h	**Air SO2**	
1.2	0.6	0.3	0.36	10	١١	0	mg/lit	**Air NH3**	
250	430	211	400	1034	1124	350	mg/lit	**Air CO2**	
0.04	0.03	0.02	0.03	0.03	0.04	1	mg/lit	**Water H_2S**	
103	64	117	76	272.8	71.7	500	mg/lit	**Ca**	
28.3	29.3	23.1	24.2	29.5	31.9	150	mg/lit	**Mg**	
0.26	0.23	0.29	0.35	2.16	0.03	0	mg/lit	**NH_4**	
678	774	547	465.4	1816.5	704.8	1300	mg/lit	**HCO_3**	
0.51	0.42	0.56	0.4	2.04	0.18	1>	mg/lit	**F^-**	
3	3	3	3	4	5	0	mg/lit	**NO_3**	
11	33	15	43	33	15	1>	MPN/100	**TCF**	**Microbial**
0	16	9	7	14	6	1>	MPN/100	**FCF**	
198	233	440	690	70	55	200>	CFU/ml	**HPC**	

The results of the relationship between sulfur-emitting gases of H_2S and SO_2 with HPC in the mineral water of six spas showed a negative relationship among them as shown in Figure 5. In other words, the presence of these dangerous gases in spa air was not only harmful to humans' health but also inhibits and controls growth of pathogenic bacteria. Low correlation among them was attributed to other side effects, such as the number and health status of the users of these spas or the use of chlorine or ozone disinfectants that can be investigated [6]. It is recommended to study the exchange of microbial colonies in humid climate of spas, which has been shown to influence water colonies [18].

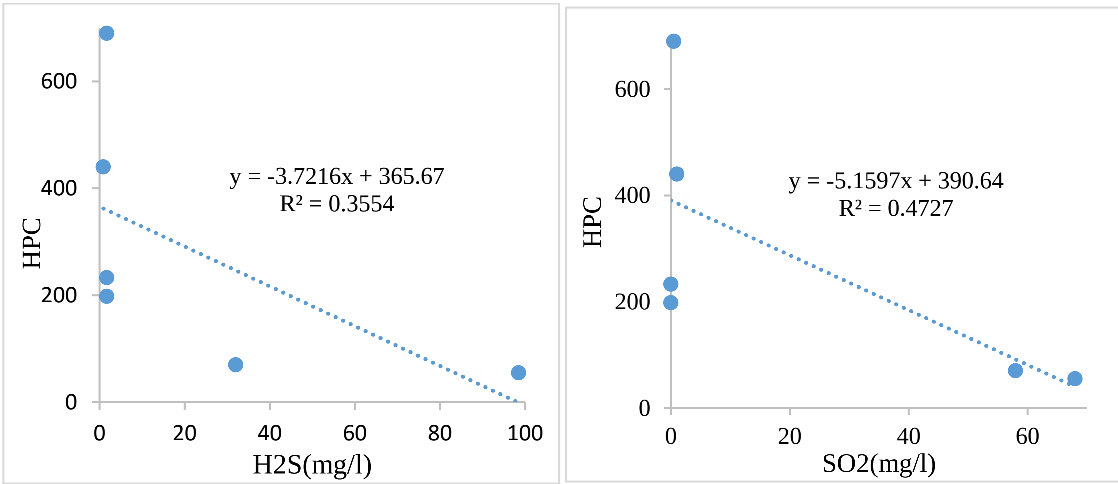

Figure 5. Negative correlation between sulfur emissions and Heterotrophs bacteria.

The results of Figure 6 showed that there was a direct relationship between spa water temperature and the amount of sulfur-emitting gases. This relationship was evident not only in one spa but also in the statistics obtained from all the six spas. Temperature was an auxiliary factor in most reactions, and in this case, it was also increased the speed of gas transfer, as completely observed in spas of QoturSuyi, Gavmish Goli, and Qinarjeh. However, due to secondary factors, such as different ventilation, chemical, and physical neutralizing gases would be an interesting cases for future studies. The existence of these relationships between the measured data confirmed the accuracy of the measurement parameters and the conceptual model of risk management presented in the present research.

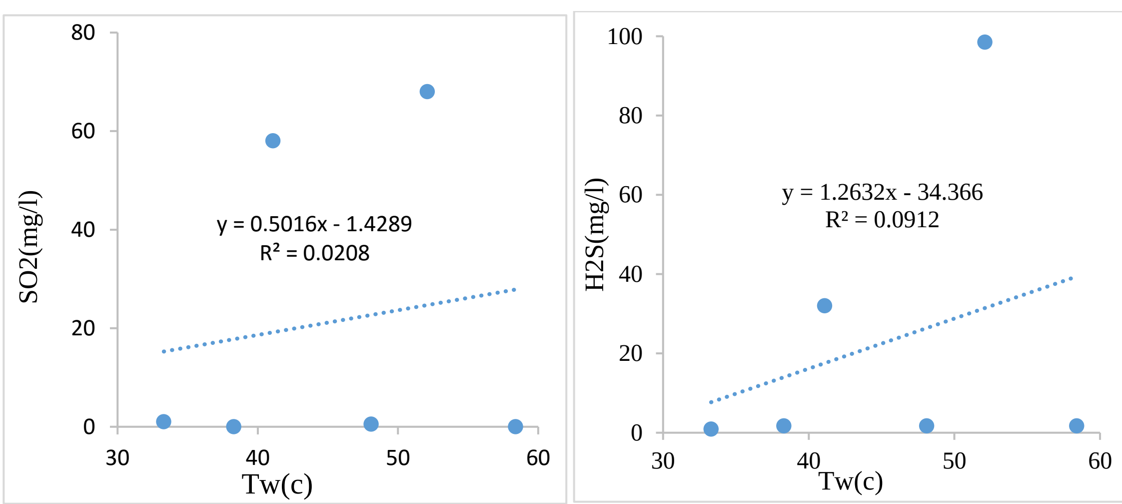

Figure 6. Positive correlation between water temperature and the amount of sulfur gases.

After reviewing the results of qualitative parameters, the risk level of each criterion was determined for the selected spas. In this section, each of the mineral spas and the relevant score was determined based on the level of qualitative parameters. The results of Table 5 showed that QoturSuyi spa with a total score of 63.5 was at a high-risk level and had the highest risk compared to the other spas studied in this study. Shabil spa with a value of 45.25 after QoturSuyi and Gavmish Goli spas (40.25) was ranked the third in terms of risk level. Qinarjeh spa with a value of 38.5 was ranked the fourth and all of them were in moderate risk level. Busheli and Sabalan spas with values of 21.5 and 22.5 had the lowest risk among the six spas and were at an acceptable level of risk.

Table 5. Value and level of risk of health, safety, and environmental parameters of the 6 spas studied

Borjloo		**Qaynarja**		**Sabalan**		**Gavmishgoli**		**Shabil**		**QoturSuyi**		**Parameter**
Risk	**Value**	**Risk**	**Value**	**Risk**	**Value**	**Risk**	**Value**	**Risk**	**Value**	**Risk**	**Value**	
0	0.04	0	0.03	0	0.02	0	0.03	0	0.03	0	0.04	**Water H2S**
8	1.7	8	1.7	4	0.9	8	1.7	0	0	16	98.5	**Air H2S**
0	0	0	0	0	0	0	0	12	88	12	58	**Air SO2**
2	1.2	1	0.6	1	0.3	1	0.36	4	10	4	11	**Air NH3**
0	250	1.5	430	0	211	0.75	400	3	1034	3	1124	**Air CO2**
0	103	0	64	0	117	0	76.2	0	272.8	0	71.7	**Ca**
0	28.3	0	29.3	0	23.1	0	24.2	0	29.5	0	31.9	**Mg**
0	678	0	774	0	547	0	465.4	1.5	1816	0	704.8	**HCO3**
0	0.51	0	0.42	0	0.56	0	0.40	0.75	2.04	0	0.18	**F**
10		**10.5**		**5**		**9.75**		**21.25**		**35**		**Chemical Risk**
0	38.4	3.5	58.4	0	33.3	1.75	48.1	0	31.1	3.5	52.1	**Water temp**
0	35	0	34	0	33	0	32	0	30	0	34	**Air temp**
1	3231	0.75	1095	1	2123	0.75	1024	1	6054	1	1121	**TDS**
0.5	6.8	0.5	7.06	1.5	6.1	1	6.2	1	6.53	2	3.1	**Ph**
1.5		**4.75**		**2.5**		**3.5**		**2**		**6.5**		**Physical Risk**
10	11	10	33	10	15	10	43	10	33	10	15	**TCF**
0	0	12	16	0	9	12	7	12	14	12	6	**FCF**
0	198	1.25	233	5	440	5	690	0	70	0	55	**HPC**
10		**23.25**		**15**		**27**		**22**		**22**		**Microbial Risk**
21.5		**38.5**		**22.5**		**40.25**		**45.25**		**63.5**		**Total**

DISCUSSION

Different researches have been conducted in the field of spa risk [22-24]. However there was a lack of risk management model with regards to the qualitative parameters. Therefore, In the current study, important physical parameters influencing chemical and microbial parameters were considered according to the findings of a study conducted in the spas of Spain [13]. The synergistic relationship between the measured data was also evident in the results of this study. There was a significant relationship between the measured data and the conceptual model of risk management presented in this research. The results of a research on hot mineral spas in Japan also emphasized that the lack of accurate and sufficient standards can cause illness and injury to the users more than its well-being and treatment aspects [14]. The results of the present study also confirmed the results of reviewing forensic documents on this issue. According to the results of researches conducted in Serbia, Yemen, and other countries, strict standards and risk management of the accidents in hot mineral spas would improve the economical situation [25]. Studies conducted in hot spas of Ardabil province, particularly in Sarein city showed that chemical and microbial parameters were not satisfied standard conditions [8], which was in line with the results of the present study. Other studies conducted in Ardabil and other mineral spas in Iran have confirmed the need to pay attention to these resources in order to improve their quality [16]. In this research, this problem was evaluated by providing a comprehensive solution and a standard qualitative model.

CONCLUSION

A risk management model seems to be necessary in mineral spas due to high presence of emitting gases, such as sulfur-emitting gases, as well as high temperature and high number of visitors to these spas for their therapeutic properties. In the fourth stage, the risk management model was provided a solution according to the nature and origin of problems, risks regarding using hot mineral spas, the results of conceptual model of risk, field visits, review of forensic records, and studies on the standard group [26]. ISO 1000 standard was divided into two categories, including defects in the system (standard development) and defects in performance of existing standards.

In the fifth step, the risk management model was presented the feedback of solutions and monitoring hot mineral spas based on the scores obtained from the third stage and the solutions proposed in the fourth step. It was found that among the six spas studied in this study, the QoturSuyi hot mineral spa with a score of 63.5 was in the high-risk level indicating the need for more monitoring and management. Forensic records related to deaths and injuries in spas also showed that the most cases belong to QoturSuyi spa, and this trend is still happening despite its decrease, and there is no written plan to reduce the number of casualties to zero. The solutions proposed in the fourth step of this model may provide a solution to this problem.

This model can be used for other indicators effective in evaluating hot mineral spas, such as health, safety, security, and spa structures. Given inefficiency regarding requirements of the current standards of hot mineral spas, the current standards should be edited by the specialized teams. It is recommended to study the effect of other microbial disinfectants, such as ozone and titanium dioxide on the number of index colonies. The increasing and decreasing effects of parameters, such as ventilation on the amount of hazardous sulfur gases should also be investigated.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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