

The Characteristic and Classification of Thermal Spring in Ramsar area, North of Iran

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ABSTRACT

Ramsar area is located across and between Alborze Mountain and Caspian Sea in North of Iran. About 30 spas are located south of the Ramsar and Sadatshar town. They are almost in between 20 to 70 m elevation. Paleozoic, Mesozoic and Tertiary rocks and alluvial deposit are exposed around the Ramsar area. In tertiary, acidic Plutonism was active and intrusion into the Paleozoic and Mesozoic formations. Quaternary and Alluvium deposits are exposed and extending on the Jurassic formations in Ramsar plain and have thickness lower than 10 m in show springs. The annual precipitation in the Ramsar region is 976 mm. There has not any proper Thermal spring management in Ramsar area yet. This could post some serious problem on improper management of Thermal spring sites, where its environment has been put into jeopardy. This study aims to provide a way to classify the Thermal springs in Ramsar area. The result of this study help in the classification of Thermal spring sites for official planning improvement of administration and sustainable development of natural resources of the area. The study makes use of the Department Applied Geosciences in Islamic Azad University and GIS data of a total of 9 Thermal springs in the attempt to set up a classification system of Thermal springs in Ramsar area. These data include surface temperature, conductivity, alkalinity, acidity, TDS, pH values, Ca, Cl, Fe, K, Mg, Mn, Na, SiO₂, SO₄ contents, their locations, usages and other relevant information. The surface temperature of Thermal springs are between 19°C – 65°C and SiO₂ geothermometer shows estimated reservoir temperature range from 86°C – 96°C. Most of the water from these Thermal springs is relatively turbidness and their composition is sodium chloride. The Thermal springs in this area generally exhibit high SiO₂ and Na content; strong smell of sulfur. In addition, there are 30 Thermal springs located in Ramsar area and that show high concentration of Cl, Ca, Na, K and Mg. There are two major criteria used in the classification system in this study, temperature and their usage. On the basis of temperature, there are three classes of Thermal springs in Ramsar area: hyperthermal spring (10%, 50-99°C); thermal spring (80%, 30-50°C). There are 4 types of usage classification: swimming pools, Tourism, space heating and drying of organic materials. There is one class achieved on the basis of pH values, all of Thermal springs exhibit weak acids.

Keywords: *Thermal spring, thermal water, chemical composition, classification*

1-INTRODUCTION

Ramsar area is located across and between Alborze Mountain and Caspian Sea in North of Iran. About 30 spas are located south of the Ramsar and Sadatshar town. They are almost in between 20 to 70 m elevation. Paleozoic, Mesozoic and Tertiary rocks and alluvial deposit are exposed around the Ramsar area. Quaternary and Alluvium deposits are exposed and extending on the Jurassic formations in Ramsar plain and is composed of fan and debris deposits and have thickness lower than 10 m in show springs. The annual precipitation in the Ramsar region is 976 mm. In tertiary, acidic Plutonism was active and intrusion into the Paleozoic and Cenozoic formations. (Fig. 1) Khazar fault is normally and longest fault in south of Caspian sea, and has NW- SE trend, in junction locally fault with N-S trend and Khazar fault thermal waters issue through these faults.(Ansari et al 2009)

There are increasing of usage of natural resources due to the population growth rate and convenient instruments used in everyday life. So there will be serious problems on sustainability and environment. Geothermal resources are one of natural resources, thus sustainable management and wise-used are needed. It is necessary to have information of all geothermal resources in this area. These data provided by BPJprogramming (Bashgah Pazhooheshgaran Javan Islamic Azad university of Iran), investigation of thermal spring in Ramsar area. This paper will inform about thermal spring geological settings, geology, chemical characteristics of Thermal springs and some classifications of Thermal springs in Ramsar area.

2. CHEMICAL CHARACTERISTICS AND DISTRIBUTION

There are a total of 9 Thermal springs in Ramsar area. The assay of these Thermal springs consist of surface temperature, conductivity, alkalinity, TDS, pH values, H₂S, Ca, Cl, Fe, K, Mg, Mn, Na, SiO₂ and SO₄ contents. The detail of some items is as follow;

2.1 Surface Temperature: The temperature measured from a total of 9 Thermal springs range between 19°C and 65°C. The average temperature is 44 °C. The Standard deviation (SD.) is 9 and median (or 50th %) is 45 °C. The Thermal springs which, temperature are higher than 65°C mostly located in Ramsar town, probably related to the fault system.

2.2 Alkalinity (HCO₃): A total of 9 assay of thermal water show HCO₃ content ranging from 442.86 and 7731.08 mg/l. The average is 1499 mg/l, with an SD. of 24.8 and the median value of 785.56 mg/l. Thermal springs in the Western part of this area have HCO₃ content higher than the median values. It may have been cause by the chemical reaction while thermal water flows through wall rocks which shale is bearing coal lens, limestone, dolomitic-limestone and dolomite.

2.3 TDS (Total dissolved solids): The 9 thermal water samples have TDS contents between 1356 and 16720 mg/l. The average is 11210.11 mg/l; the median is 13500 mg/l. Most of Thermal springs in this area have high TDS (>1,500 mg/l) especially those Thermal springs located near the junction of NW-SE and N-S faults in Ramsar area.

2.4 pH : The pH values of 9 Thermal springs show a range between 5.5 and 6, with an average of 5.8, the median value of 6. Most of Thermal springs are weak acid spring.

2.5 Ca, Cl, K, Mg and Na: The Ca content of thermal water has a range between 285948 and 3635254 µg/l. The average is 922999.7 µg/l with an SD, Of 319.23 and the median value of 726545 µg/l. One of the reasons of high Ca is flowing through mineralized veins related with

Tertiary plutonism and carbonate units of thermal water in Ramsar region. The Cl content of thermal waters has an assay 16 to 62903 $\mu\text{g/l}$. The average is about 12636.7 $\mu\text{g/l}$, with an SD. of 155.06 and the median value of 8961 $\mu\text{g/l}$. Following Groundwater acts in 1991; standard drinking has Cl content less than 200 mg/l, brackish water has Cl content about 1,400– 3,000 mg/l and salty water has Cl more than 3,000 mg/l. Most of Thermal springs in this area have Cl content less than 200 mg/l. The K content of thermal water is between 6765 and 187925 $\mu\text{g/l}$. The average is about 51132.33 $\mu\text{g/l}$, with an SD. of 122.36 and a median value of 42012 $\mu\text{g/l}$. Most of thermal waters have medium K content. The Mg content of thermal water has arranged between 120886 and 893703 $\mu\text{g/l}$. The average is about 249722.4 $\mu\text{g/l}$, with an SD. Of 127.36 and the median value of 202128. The Na content of thermal water shows ranging from 35789 to 32600000 $\mu\text{g/l}$. The average is 6705330 $\mu\text{g/l}$, with an SD. Of 123.89 and the median value of 4942747 $\mu\text{g/l}$. The contents of Ca, Cl, K and Mg in thermal water are high concentration of these elements in some Thermal springs.

2.6 Fe (iron) : The Fe content of 9 Thermal springs has range from 754 to 8849 $\mu\text{g/l}$. The average is 2287.33 $\mu\text{g/l}$, the SD is 138.334 and the median is 1311 $\mu\text{g/l}$. Most of them have Fe content higher than 1 mg/l; this value is the standard drinking water of Groundwater acts in 1991. To solve high Fe content in the water is to fill oxygen in to water, and related with infiltration mature water and interaction with mineralized and Alteration veins.

2.7 Mn (manganese) : The Mn content of 9 Thermal spring samples range from 37.43 to 463.26 $\mu\text{g/l}$. The average is about 92 $\mu\text{g/l}$, the SD is 91.199 and the median value equals to 46.85 $\mu\text{g/l}$.

2.8 SiO₂ (silica) : A total of 9 assay of thermal water show SiO₂ content from 2.15 to 19 mg/l. The average is 4.6 mg/l, and a median value of 2.52 mg/l. Thermal springs have low SiO₂ content in this area.

2.9 SO₄ (sulfate) : The SO₄ content of 9 Thermal springs has a range between 152 mg/l and 247.2 mg/l. The average is 204.13 mg/l, with an SD. of 8.06 and a median value of 216.71 mg/l. The Thermal springs having high SO₄ are mostly located in the spas.

Cl-SO₄-HCO₃ triangular diagram (Giggenbach, 1991) in Figure 2, Ca-Na-K equilibrium triangular diagram and Ca-Na-Mg equilibrium triangular diagram (modified from Hen, 1959; Giggenbach, 1991 and Arnorsson, S. 200) in Figure 3 and Figure 4 present property of thermal water in the Ramsar area. Cl-SO₄-HCO₃ triangular diagram shows that some of thermal water are located near the bicarbonate region such as Safarod and Absiah thermal springs and they are known as (Peripheral Waters) due to absorption of deep CO₂ and to the mixing with shallower water. Most of thermal water property is saline water and located near the Cl content also related with Mature water area. In Figure 3 and Figure 4 There are approximately 90% of total numbers of Thermal springs water samples show high Na content. On the basis of result from the chemical analysis of SiO₂, Na, K, Ca and triangular geothermometers (Figure 5) were then calculated to estimate reservoir temperature (Fournier, 1981), (Giggenbach 1991). The estimated reservoir temperatures from the equations above are summarized in Table 1. Estimated temperature from triangular geothermometers (Giggenbach 1991), is approximately the same as the temperature obtained from quartz no stream loss, quartz maximum stream loss, where as Na-K-Ca geothermometer shows higher estimate temperature and the highest estimate temperature is Na/K and Na-K-Ca-Mg geothermometer, and triangular geothermometer is shown reservoir temperature between 100 °c to 120 °c.

3. CLASSIFICATION OF THERMAL SPRING

There are many criteria to classify Thermal springs such as temperature, pH, chemical composition etc. These criteria depend on purpose or object of classification. The object of these classifications is to sustainable management and development.

3.1 Temperature Classification: There are 3 types of Thermal springs classified by surface temperature as follow; The 7 data of springs in Ramsar indicated that Thermal springs (80%) are thermal springs, where as 1 Thermal springs (10%) are hyperthermal springs.

3.2 pH Classification: Thermal springs in Ramsar have 1 classes on the basis of pH. These are weak acid spring . (pH = 4–6).

3.3 Usage Classification : There are 3 types of this classification: Electric power generation plant, swimming pool and Tourism, House heating and Greenhouses. There are approximately 13% of Thermal springs used in tourism purpose. The Electric power generation plant of Thermal springs in Ramsar is approximately 70%, where 17% of Thermal springs in this area use to House heating and Greenhouses. It is useful to know status of all Thermal springs, if sustainable development of geothermal are needed.

4. CONCLUSION

Most of Thermal springs in Ramsar are classified in sodium chloride, some of them are calcium sulfate water. In the thermal water generally exhibits strong smell of sulfur and high SiO₂ contents. The surface temperature is between 19°C – 65°C. The SiO₂ geothermometer shows estimated reservoir temperature range from 86 °C – 96°C. here are two types of Thermal spring classification system; temperature and geothermal usage. On the basis of temperature, there are three classes of Thermal springs in Ramsar: 10 % of Thermal spring is hyperthermal spring (50- 99°C) and 80% show thermal spring (30-50°C). The last classification is geothermal usage. They are classified in 3 types: There are approximately 13% of Thermal springs used in tourism purpose. The Electric power generation plant of Thermal springs in Ramsar is approximately 70%, where 17% of Thermal springs in this area use to House heating and Greenhouses.

Extremity , suggestion to exploration to deep(reservoir > 1000 m depth), is essential for assessment of deep reservoir potential and identifying the up flow zone. The present discharge may be used for direct heat uses viz. spa, greenhouse cultivation, food industry and tourist attraction.

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Table 1: estimated reservoir temperature from 9 type of geothermometer

	1	2	3	4	5	6	7	8	9
	Qtz no	Qtz Max	Chalcedony	α -Cristobalite	Na-K	Na-K-Ca	Na-K-Ca-Mg	Mg-Li	Na-Li
H1	88.744 [□] c	91.219 [□] c	57.929 [□] c	38.66 [□] c	<150 [□] c	95.318 [□] c	>350 [□] c	38.347 [□] c	38.347 [□] c
H2	88.868 [□] c	91.327 [□] c	58.061 [□] c	38.781 [□] c	<150 [□] c	94.391 [□] c	>350 [□] c	38.71 [□] c	50.304 [□] c
H3	93.248 [□] c	95.14 [□] c	62.72 [□] c	43.044 [□] c	<150 [□] c	95.462 [□] c	>350 [□] c	39.109 [□] c	50.821 [□] c
H4	92.005 [□] c	94.059 [□] c	61.396 [□] c	41.832 [□] c	<150 [□] c	92.125 [□] c	>350 [□] c	38.386 [□] c	48.489 [□] c
H5	85.9 [□] c	88.737 [□] c	54.914 [□] c	35.809 [□] c	278.41 [□] c		<0 [□] c	13.571 [□] c	181.85 [□] c
H6	83.558 [□] c	86.7 [□] c	52.436 [□] c	33.6 [□] c	<150 [□] c	94.081 [□] c	>350 [□] c	55 [□] c	41.647 [□] c
H7	94 [□] c	96 [□] c	63 [□] c	44 [□] c	<150 [□] c	99.543 [□] c	>350 [□] c	55 [□] c	41.647 [□] c
H8	94.551 [□] c	96.272 [□] c	64.11 [□] c	44.03 [□] c	<150 [□] c	195 [□] c	>350 [□] c	47 [□] c	75 [□] c
H9	91.4 [□] c	93.5 [□] c	60.7 [□] c	41 [□] c	<150 [□] c	107 [□] c	>350 [□] c	45 [□] c	78 [□] c

1) Fournier (1977); 2) Fournier (1977); 3) Fournier (1977); 4) Fournier (1977); 5) Fournier (1979); 6) Fournier & Truesdell (1973); 7) Kharaka, Y.K. and R.H. Mariner, (1989); 8) Kharaka, Y.K. and R.H. Mariner, (1989) 9) Kharaka, Y.K. and R.H. Mariner, (1989).

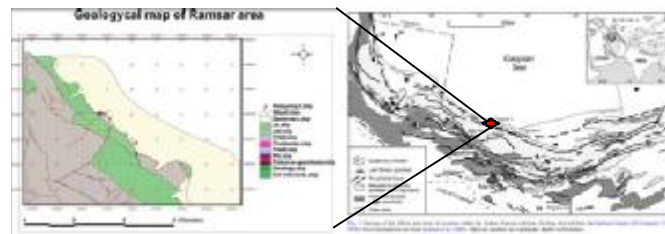


Figure1: Geological map of Ramsar area.

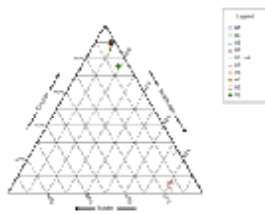


Figure 2 : Cl-SO₄-HCO₃ triangular diagram of thermal spring in Ramsar

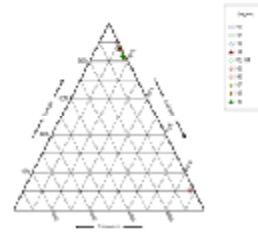


Figure 3 : Ca-Na-K diagram of thermal spring in Ramsar

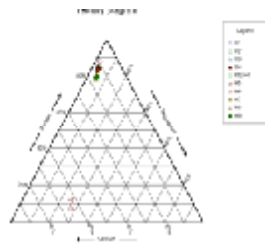


Figure 4 : Ca-Na-Mg diagram of thermal spring in Ramsar

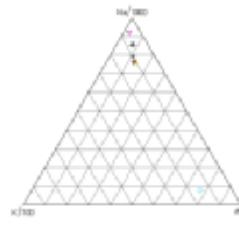


Figure 5 : Na/1000-K/100-√Mg diagram of thermal spring in Ramsar