International conference
ON MODERN RESEARCH
IN AGRICULTURAL SCIENCE
AND ENVIRONMENT
December 15, 2015
MALAYSIA – KUALA LUMPUR

کـنفرانس بین الـمللی
پژوهش هـای نویـن
در علـوم کشــاورزی
و محیــط زیســت
۲٤ آذر ماه ۱۳۹٤
کوالالامپور - مالزی

A study on the environmental impact of boron and hydro-geochemical elements of Isti Su Hot Spring in Salmas, Western Azerbaijan, Iran

Gohar Farajpour
Department of Geology, Shahid Beheshti University, Iran
gfarajpour@gmail.com
Mohammad Yazdi
Department of Geology, Shahid Beheshti University, Iran
Pedram Navi
Geological Survey and Mineral Exploration of Iran

Abstract

Throughout history, hot springs have been of undeniable effects on human's life, even animals benefit from natural hot springs. Some of these waters, because of having some chemical materials, hold a particular color, odor or taste and they are used enormously in the fields of health and tourism. boron is derived from geothermal sources, and is leached from many varieties of rocks. Normally, Boron concentration in the hydrothermal and geothermal solutions for water rise higher than its standard level for water High B concentrations can cause human health effects. Additionally high B concentrations can have a detri mental effect to crops. So, aimed at this purpose, studying these springs from an environmental perspective is of vital importance. In this paper, Isti Su's hot spring in Ab-e-Garm Village located in the city of Salmas was studied .Regarding the importance of the dangers emerged due to excessive amounts of these dangerous elements after the geochemical measurements of water samples to determine the water type, drawing diagrams and comparing the values obtained with national and international standards, it was concluded that the As, B, Li, Fe, Hg, Na, and Cr elements' levels are over the permitted level. As a result, the inappropriate use of this natural phenomenon can bear harmful negative effects on the environment and human beings.

Keywords: hydrogeochemical elements, environmental impact, hot spring, Salams, Iran

Introduction

The study area is located in the Abegarm, Salmas city in West Azerbaijan, the location of the study area is shown in (Fig 1). In the Salmas city of a magma chamber as a heat source and is abundant rainfall for wet snow and rain, as well as fault causing the permeability of the area that created the conditions for the creation of hot springs hydrothermal system.

Hydrothermal activity generates chemical interactions between hot water (hydrothermal fluid) and the host rocks, so that the composition of the fluid changes, becoming enriched in many trace elements (e.g. V, Co, Ni, Cu, Zn, As, Se, Al, Ag, Cd, Sb, Cs, Ba,W, Au, Tl, Pb and REE; German and Von Damm, 2003). Natural B is derived from geothermal discharges, leaching from a large variety of rocks, or the mixing of groundwater with oil field water or connate or fossil brines. High B concentration of thermal waters Cause environmental problems in groundwaters and surface waters (Gemici and Tarcan, 2002; Vengosh et al2002). Craw et al., 1999, Axtmann).

Type and origin of these springs have a major role in determining their physical and chemical properties to different sources at the same event that has completely different properties, some are pathogenic and sometimes healing to many factors such as the source of spring water, the composition of ground water that has passed, pressure, temperature, speed and time depends on the flow of water in the ground (GHafouri 2003)

The water fountain with cold spring water may be mixed gravity. Seasonal trends and mixed shrinkage at spring mechanism plays a role (2010 Kresic).

In this study environmental Impact, and hydrochemical characteristics hot spring located in the South East of the city of Salmas to Isti Su (located at 67 km of roads Urmia - Salmas) have been studied.

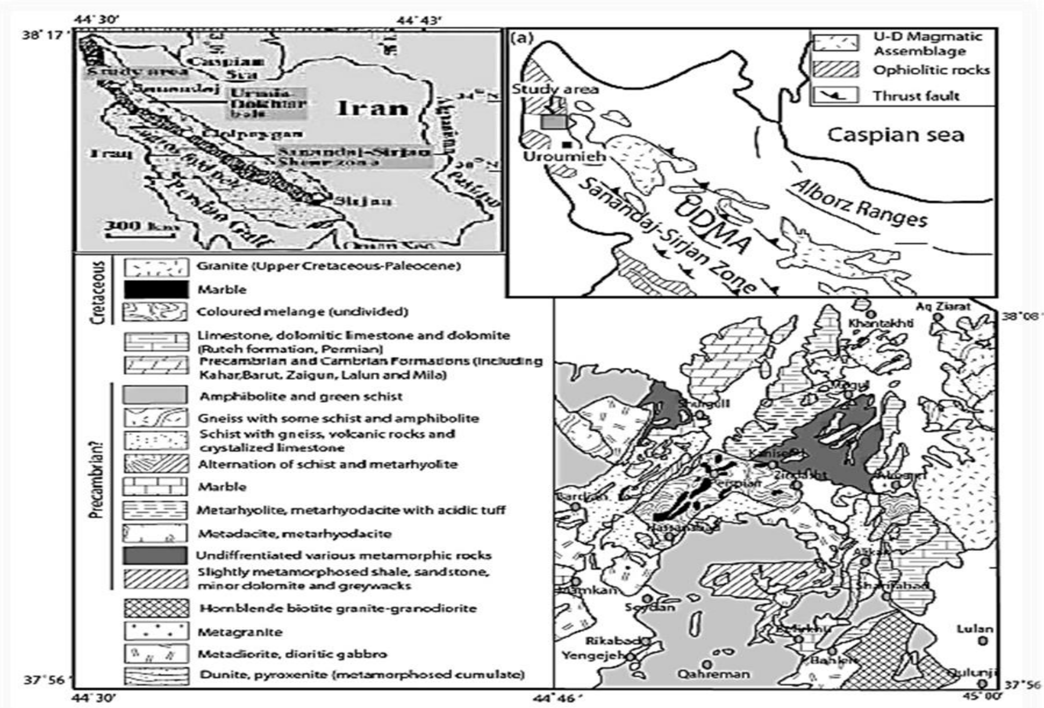

Fig1.Location map of the Istysoy area (a, b). (a) (Alavi et al. 1994,(b)Geological map of Salams area (KHodabande et al.2002)

Geologic Setting

Study area is located in north-western Iran, according to Iranian sedimentary dividing the building blocks (Stocklin, 1968), this area is part of the transformation and ophiolite belt Sanandaj –Syrjan zone. Collection of igneous sedimentary units (Formation Khar, Barot, Zagon , Lalun .myla) were deposited in continental platform .intrusive rocks in area include Qushchi granite and ophiolite complex consists of meta- granite ,basic rocks and ultramafic part sepentinized, the meta-basalt, green schist, meta-diorite and marble. The lower part of the Qom Formation (limestone cream and milky Rifi, marl colors, gray), the upper part Ruteh Formation (dolomite, dolomitic lime, limestone), Quaternary units of young alluviums and plain deposits and old terraces alluviums, in the Precambrian period - Paleozoic (metamorphic rocks of unknown age) are included.

Sampling Method

A total of 8 thermal water samples were collected from the area. In order to investigate the seasonal changes of field and chemical parameters and to trace element concentrations in dry and wet seasons .Hot spring waters were collected Month of May and July. Water samples were collected into250-ml plastic bottles containers.The water samples were collected as two filtered batches. 2.5-ml ultrapure Merck HNO3 was added into one of the batches for cation analyses. Temperature, pH and electrical conductivity (EC) of the water samples were measured on-site The other batch taken for anion analyses was untreated Water analyses were performed using standard methods in the ‘‘Geological Survey of Iran’’ Laboratories. Bicarbonate and chloride analyses were measured by titration methods, sulfate concentration by spectrophotometry and cations by flame photometry. Acidified samples were analyzed for major and trace elements with an ICP-OES method.

Results

Water chemistry

The results for Chemical analysis are given in Table 1.

Table1(Chemical analysis results of the Isti Su hot springs (mg L−1)). (Dry season)

Parameter	Isti Su	HS2	WHO
Temp. (ºC)	37.6	26	
pH	7.5	6.4	6.5-8.5
TDS	9200	1790	1,000
EC (Ms/cm)	14750	3146	2,000
Ca (mg L^{-1})	11	311	1,000
K (mg L^{-1})	193	11.5	50
Mg (mg L^{-1})	16.6	116	10
Na (mg L^{-1})	3788	97.7	30
Cl^- (mg L^{-1})	1064	2.5>	200
SO_4^{2}- (mg L^{-1})	3284	213	250
CO_3^{-2} (mg L^{-1})	420	0.3>	
$HCO3^{-}$ (mg L-1)	7800	1464	250

Table 2(Chemical analysis results of the Isti Su hot springs (mg L^{-1}). (Wet season)

Ag	<0.01	<0.01	0.1
Al	0.148	0.07	
As	>100	<1	0.01
B	>100	4.617	0.5
Ba	0.735	0.167	0.7
Be	<0.01	<0.01	
Co	<0.01	<0.01	
Cd	<0.01	<0.01	0.003
Cr	0.496	0.299	0.05
Cu	0.054	0.011	
Eu	<0.01	<0.01	
Fe	<0.01	<0.01	

Gd	0.631	0.011	
Ge	1.101	0.0180	
Hf	<0.01	<0.01	
Hg	0.218	<0.01	0.001
Ir	<0.01	<0.01	

Temperatures of the thermal springs range from 26 to 37.6 C. According to the temperature categorization by Kovačić the Perica (1998), the spring water in the spring water in Isti Su is thermal. PH values in th samples were between 6.40 and 7. 5 (Table 1). The pH is controlled by dissolution of gases (such as CO2, H2S, NH3, CH4) which are entering the aquifer system and geochemical processes such as the synthesis and mineralisation of biomass, redox processes etc. in the aquifer. The higher the amount of dissolved gases in the aquifer system, the lower the pH value will be. The highest EC value is observed at the Isti Su hot springs, with a value of 14750 to 3146 mS/cm. The EC value is influenced by the amount of dissolved solids in the water. If the water contains a high amount of dissolved solids, the EC values will be higher, and vice versa. Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. TDS contents of the thermal waters range from 9200 to 1790(mg L^{-1}). The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, bicarbonate, chloride, sulfate, and nitrate anions (WHO 2003). Water containing TDS concentrations below 1,000 mg/liter is usually acceptable to consumers, although acceptability may vary according to circumstances However, the presence of high levels of TDS in water may be objectionable to consumers owing to the resulting taste and to excessive scaling in water pipes, heaters, boilers, and household appliances (WHO 2003).

Major ions

Major ion concentrations are also in Table 1 and spring waters areplotted in the Piper diagram in Fig. 2. The Piper plot shows that cations in the springs generally plot in the sodium plus field. Most anions in the Piper plot show that the springs generally HCO_3^-. In the Isti Su hot spring, the water is of Na-SO4-HCO3 type. These values (Table I) were also plotted in the Schoeller diagram (Schoeller1962), the diagram (Figure3) depicts the following arrangement of anions and cations :(Na^++k^+)>Ca^+>Mg^+,HNO_3^-> SO_4^{-2}>CL^-. The results derived from the Piper diagram are compatible with those obtained from the Schoeller diagram. Therefore the high mineral hot springs were not suitable for drinking. Wilcox graph was plotted for hot spring. Wilcox graph based on two criteria in irrigation water SAR (sodium levels) and specific electrical conductivity (salinity hazard) divided into 16 categories. C1S1 water level best and worst C4S4 water for use in agriculture.

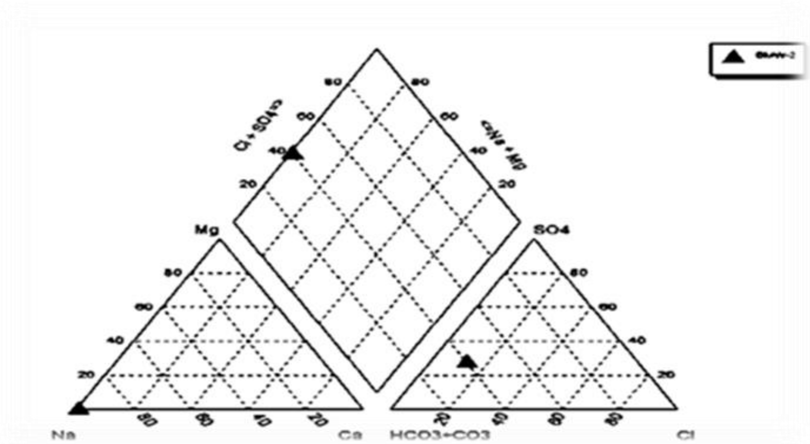

Fig 2. Piper trilinear diagram for spring water classification in the area (dry season)

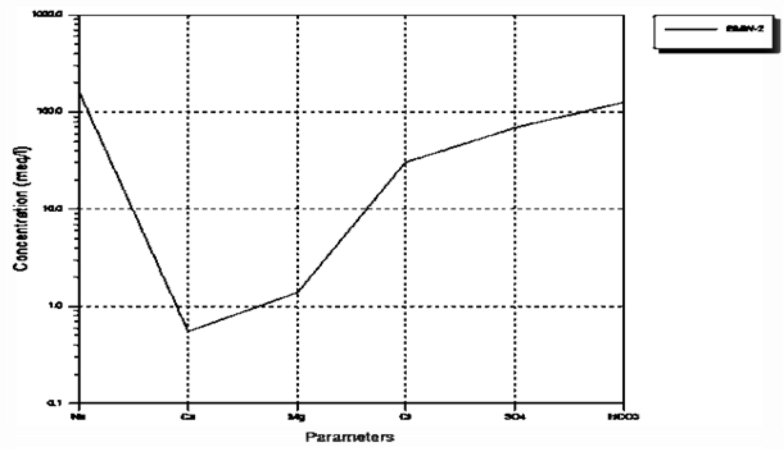

Fig 3. Schoeller diagram of the ISti Su hot springs (dry season)

Trace elements in spring waters

Trace element analyses show the distribution of pollutants in the water samples. These analyses show that some ions such as SO4, and those of As and B are enriched.

Enrichment of B, As and some major and trace elements in hot spring is directly related to the leaching of the limestone rocks .The hot water emerge as springs along fracture zones and contacts of the limestones.

Hot springs are formed when water percolates through permeable rock or fractures, is heated by the earth's crust at depth, and is then driven to the earth's surface by a combination of artesian flow and thermal convection Woodsworth, 1997. Hot water is able to dissolve minerals over time, so that elevated levels of metals and metalloids are often associated with hot springs. Of the various sources of As in the environment, drinking water probably poses the greatest threat to human health (Smedley and Kinniburg2002). In our study area we observed high concentrations of As, Sb and B in the hot spring fluids which have a direct impact on human health through mixing with freshwater resources used for drink ing and irrigation. For example, high As and B concentrations has carcinogenic effects to human health and potentially accumulate in agricultural produce. High B concentrations can cause human health effects. Additionally high B concentrations can have a detri mental effect to crops. (Gunduz et al, 2010).

The studied geothermal waters contain higher concentrations of As, B, and other trace elements relative to WHO drinking water guidelines.

Hydrothermal waters change their physical and chemical nature during their rise from the deep geothermal reservoir to or near to the earth's surface due to physical, chemical and biological processes. (Chandrasekharam D, Bundschuhj.2008).

Conclusions

Thermal spring Isti Su are characterized by having high salinity (Na, Cl) and near neutral pH; major ion composition shows Na,Cl and HCO3 as predominant ions. Chemically, the thermal waters are of NaCl and Na-SO- HCO_3^- types which confirm the influence of the geological formations dominated by carbonate and evaporate rocks. The studied Hot spring contain higher concentrations of As, B, and other trace elements relative to WHO . The boron concentration is high in the hot spring, which reduces the efficiency of agricultural production and the toxic effects that are leaves yellowing and drying out. Soil that is irrigated with contaminated water may not show in the early years of the adverse effects of boron toxicity but with the accumulation of boron in the long term they may be totally eliminated .In the Isti Su area the diffusion of As and B spring waters into aquifers could contaminate the groundwater used for drinking purposes. Also, the thermal spring discharges into the streams and rivers could affect irrigated crops in downstream fields. Contamination of water resources creates numerous problems for residents.

References

-Alavi M. 1994. Tectonics of Zagros Orogenic belt of Iran, new data and interpretation, Tectonophysics 229: 211-238

-Aghanabati A., 1990. Explanatory Text of the Bakhtaran Quadrangle Map 1:250.000, Geological Survey of Iran.

- Baba A. and H. Ármannsson, 2006, Environmental impact of the utilization of a geothermal area in Turkey, Energy Source 1 267–278.

Chandrasekharam D, Bundschuh J., 2008, Low-enthalpy geothermal resources for power generation. 1st ed. The Netherlands: CRC Press/Balkema; Francis & Taylor.

-German, C.R., Von Damm, K.L., 2003. Hydrothermal processes. In: Holland, H.D., Turekian, K.K. (Eds.), Treatise on Geochemistry. Elsevier, pp. 181 –221

-Ghafouri MR., 2003, Mineral water and mineral springs of Iran, University of Tehran, Tehran publication.

- Gunduz C., Simesk,A, Hasozbek, 2010, Arsenic pollution in the groundwater of Simav Plain, Turkey: its impact on water quality and human health, water Air soil pollut,205, 43-62.

-Kresic N., 2010, Types and classifications of springs Groundwater Hydrology of Springs, 2010, Pages 31-85.

- Khodabandeh, A.A., Soltani, G., Sartipi, A., 2002, Geological Map of Salmas, Scaled 1:100,000. Geological Survey of Iran, Tehran.

-Piper, Arthur M., 1994, A graphic procedure in the geochemical interpretation of water-analyses." Eos Transactions American Geophysical Union 25.6: 914-928.

-Schoeller.H, 1962, Les eaux souterraines, Masson & Cie, Paris, 642pp.

-Smedly PL,Kinniburg DG,A., 2002, Reviw of the source ,behavior and distribution of arsenic in natural waters ,appl Geochem;17:517-68.

-Stocklin, J., 1968. Structural history and tectonics of Iran: a review- The American Association of Petroleum Geologists Bulletin 52 (7), 1258-1229.

-Taheri M, Yazdi M, Navi P (2012a) Health hazards and arsenic pollutants in Kharaqan Hot springs, Qazvin. In: proceedings of4th Symposium of Iranian Society of Economic Geology, August 30–31, Birjand university.

- Tarcan G., and U. Gemici, 2005, Effects of the contaminants from Turgutlu–Urganlı ther-momineral waters on cold ground and surface waters, Bull. Environ. Contam.Toxicol, 74 : 485–492.

-Vengosh,A.,Helvaci,C.,Karamanderesi,i.H.,2002.Geochemical constraints for the origin of thermal waters from western Turkey. Appl. Geochem.17, 163-183.

WHO, 2011, Guidelines for drinking-water quality, World Health Organization. 4th edition. On line: http://www.who.int/publications/2011/9789241548151_eng.pdf

WHO. 2003 Arsenic in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality. Geneva, Switzerland: World Health Organization, WHO/SDE/WSH/03.04/75.

Wilcox L.V, 1948, the Quality of Water for Irrigation Use, U.S. Dept. of Agriculture, Bull. 962., Washington, 19p.