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# Water Chemistry of Hot Springs in Gizan Area of Saudi Arabia

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**Abstract.** The water chemistry of two natural hot springs in the Gizan area was studied with particular reference to the water quality of another spring in the middle part of Saudi Arabia. The mean maximum temperatures and pH values recorded were 50°C and 8.1 for Ain Al-Harra and 57°C and 7.8 for Ain Al-Khoba respectively . Conductivity was 3200 $\mu$S cm$^{-1}$ for Ain Al-Harra, 2700 $\mu$S cm$^{-1}$ for Ain Al-Khoba, which was higher than at Al-Qasseem. Sodium at 350 mg/1 and calcium 159 mg/1 are the recorded maxima in comparison to the other hot spring at Al-Qaseem Saudi Arabia. The other relatively high constituents were chloride 346 mg/1 and potassium 347 mg/1. Ammonia and nitrate were found to be below the detection limits of 0.001 mg/1. The elements iron, manganese, magnesium, and zinc were present in low quantities. Both springs were dominated by blue-green and green algae, which demonstrated a marked temperature gradient; blue-green algae were present at the high temperatures of 45-50°C at Ain Al-Harra and 50-57°C at Ain Al-Khoba, followed by filamentous green algae at lower temperatures in the downstreams.

## Introduction

In view of the arid nature of Saudi Arabia, it is quite common to find warm inland water bodies, because of high radiation. According to Dreaver *et al.* [1], Saudi Arabia receives the highest solar energy load over the Arabian peninsula but only very few of the water bodies are hot springs.

The Gizan region has also numerous artesian springs but a few are really hot springs such as Ain Al-Harra and Ain Al-Khoba. In the neighboring Arabian peninsula hot springs are found in Bahrain [2], Nakhl (Todmor) of Oman [3] and north east Mukalla [4, 5].

Groups of hot springs have also been reported from other parts of the world. The greatest thermal springs occur in the Yellowstone plateau of North America, the North island of New Zealand [6], Iceland [7] and Japan [8, 9]. Also large numbers of hot springs are scattered over most of the United States, Italy, Algeria, Greece, Tunisia, Turkey and some of the Asian countries [10, 11].

Apart from the studies of Arif [12] and Aleem *et al.*, [13], in central part of the country almost nothing is known about the water chemistry and vegetation of the hot springs in Saudi Arabia. The present study therefore investigates the water chemistry of two hot springs in the Gizan region which is different in topography from the central province. That is because of the mountains which almost surround Gizan, where rainfall occurs in relatively high quantities and runs throughout the plateau of the Gizan coastal plain [14].

## Study Area

The Gizan area of Saudi Arabia is a part of South Tihama with a steppe type of the coastal plain, which stretches some 300 km along the Red Sea coast and is 30 to 40 km wide. It extends between 16° and 18° N Latitude and between 41° and 45° E Longitude (Fig. 1). The area is intersected by several wadis that run from the mountains to the coastal regions. The mountains in the east are high, ca. 1800 m above sea level. Several artesian springs arise from them, some forming large oasis, but very few seem to be hot springs.

### Meteorology

Temperature in Gizan area is very high from April to September with a peak value of 49°C. According to the Annual Environmental Report of the Saudi Arabian General Directorate of Meteorology [15], the mean monthly temperature ranges between 24°C and 34°C with a minimum of 20°C in January and February. Between July and September the khamsin blows as seasonal stormy winds, followed by sand and dust storms. Humidity is always fairly high, with a daily average range being between 60% and 80% and a miximum of 90% occurring in July and August. Rainfall varies greatly from year to year; the average was 13 mm recorded in Tihama, while in the mountains it reached 30 mm or more. High temperature values were recorded for both the studied sites and conspicuous thermophilic algae occurred near the orifice of springs.

### Description of hot springs

Gizan hot springs are present near the basin of Hejaz mountains. The water passes through holes producing small downstreams that form shallow pools used for

bathing and balneotherapy. The two hot springs studied in (Fig. 1) are as follows:

(1) ***Ain Al-Harra*** (Site I) is about 35 km NE of Gizan town, the spring is 1.5 meter wide and 1 meter deep. The water flows downstream by gravitational force and the run-off is discharged in a drainage canal which ultimately ends in an evaporation lake.

(2) ***Ain Al-Khoba*** (Site II) is about 55 km SE of Gizan town, it measures 5 meters wide and upto 1 meter deep.

Both sites were dominated by visually obvious blue-green algae forming a thin film over the bottom sediments; this film stretched in the form of continuous mat.

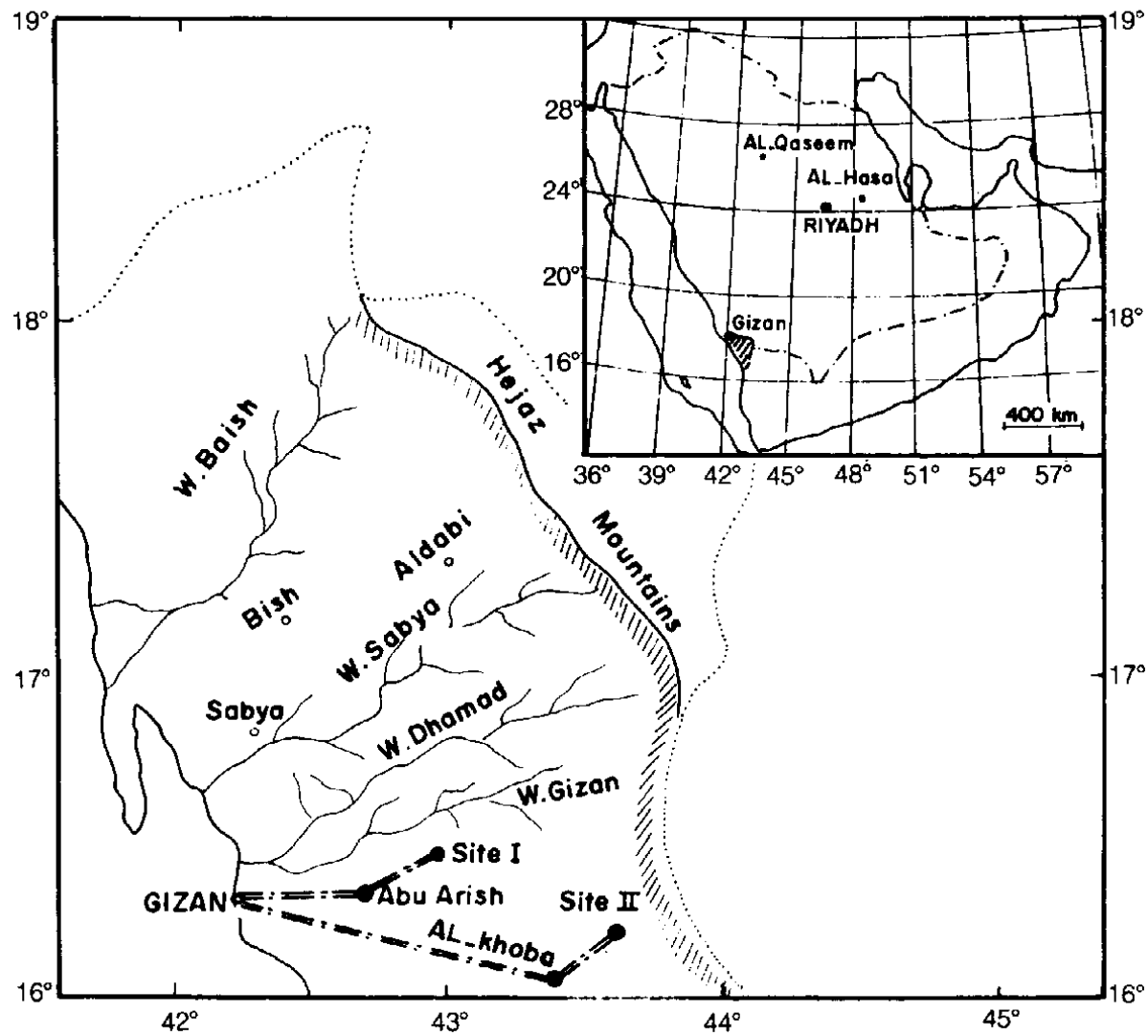


**Fig. 1. General map of Saudi Arabia and enlarged part of the Gizan area showing the location of the two hot spring sites.**

## Materials and Methods

Temperatures were measured by using a mercury thermometer or a thermistor type meter (ATS/5009). Hydrogen ion concentration and conductivity were determined by using a corning pocket pH meter and a conductivity bridge (WTW/FL 56). All these were measured at both sites. Single water samples were collected from these sites in a 500 ml polythene screw cap bottles and brought to the laboratory in an ice box. The samples were chemically analyzed for the elements Na, Ca and K by flame photometry [17]. The remaining elements Mg, Mn, Fe, Zn, were determined by using atomic absorption spectrometry, (Py-Unicam sp 9) following the methods of Allen *et al.*, [18] as described by Basahy [19]. N-$NO_3$ and F were measured by a Hach (DR-EL/2) portable spectrophotometer. Cl was determined by a titrametric method. All values reported are the mean of triplicate measurements.

## Results and Discussion

As shown in Table 1, the mean maximum temperature and pH values recorded were 50°C and 8.1 for Ain Al-Harra and 57°C and 7.8 for Ain Al-Khoba, respectively. Conductivity measurement was 3200 $\mu$S $cm^{-1}$ for Ain Al-Harra and 2700 $\mu$S $cm^{-1}$ for Ain Al-Khoba.

**Table 1. Physical and chemical properties of the studied hot springs sampled on 15-18 November 1988 and from Al-Qassem (concentration in mg/l)**

| Sites | Site I Ain Al-Harra | Site II Ain Al-Khoba | Al-Qassem* |
|---|---|---|---|
| Temperature | 50°C | 57°C | 60°C |
| pH | 8.1 | 7.8 | 7.5 |
| Conductivity | 3200 $\mu$S $cm^{-1}$ | 2700 $\mu$S $cm^{-1}$ | 1212 $\mu$S $cm^{-1}$ |
| Sodium | 320 | 350 | 264 |
| Calcium | 122 | 159 | 113 |
| Potassium | 347 | 331 | – |
| Magnesium | 9.4 | 3.8 | 22.6 |
| Manganese | 0.01 | 0.12 | 0.99 |
| Iron | 0.06 | 0.08 | 0.73 |
| Zinc | 0.01 | 0.02 | 0.055 |
| Ammonia | – | – | – |
| Nitrate | – | – | 0.44 |
| Fluoride | 2.15 | 3.14 | 0.21 |
| Chloride | 346 | 337.5 | 450 |

*Arif (1983)

The water in both springs was found to have a higher concentration of sodium and calcium than those recorded by Arif [12]. Nitrate and ammonia were below the detection limits in both springs. The low concentrations of iron, zinc, manganese and fluoride are different from other hot springs reported from elsewhere [20]. The water chemistry of Al-Qassem hot spring, as reported by Arif [12], showed a relatively higher concentration of chloride 450 mg/l and magnesium 22.6 mg/l.

Most parts of both springs are overwhelmingly dominated by thermophilic algae particularly at parts with higher temperatures. Establishment of these start from 50°C for Ain Al-Harra and 57°C for Ain Al-Khoba. *Synechococcus lividus* Copeland occupied the higher limits, followed by *Mastigocladus laminosus* Cohn. in both springs. The other related algae, at the lower temperatures thrive at 25°C in Ain Al-Harra, whereas in Ain Al-Khoba at 27°C. However, in both downstreams the filamentous green algae *Cladophora* and/or *Spirogyra* are the immediate successors.

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# كيميـاء الينابيـع الحـارة بمنطقة جيزان بالمملكة العربية السعودية

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(سُلِّمَ في ١٧ رجـــب ١٤١٣هـ، وقُبل للنشر في ١٤ ربيع ثاني ١٤١٤هـ)

**ملخص البحث.** لقد تمت دراسة بعض الخواص الفيزيائية والكيميائية لاثنين من الينابيع الحارة الطبيعية بمنطقة جيزان، وكانت متوسطات درجات الحرارة العليا والرقم الهيدروجيني للمياه على النحو التالي:

- ينبوع العين الحارّة درجة حرارته ٥٠°م ورقمه الهيدروجيني ٨,١، بينما درجة الحرارة في ينبوع الخوبة كانت ٥٧°م ورقمه الهيدروجيني ٧,٨.
- أما التوصيل الكهربائي لهما فقد كان على التوالي ٣٢٠٠ و ٢٧٠٠ ميكروموز/سم وهذا أعلى بكثير من ذلك المسجل في ينابيع القصيم، وكانت تراكيز كل من الصوديوم والكالسيوم على التوالي هيَ ٣٥٠ ملجم/ لتر و ١٥٩ ملجم/ لتر وهذه أعلى من مثيلاتها في ينابيع القصيم الحارّة.
- العناصر الأخرى المرتفعة نسبيًّا في الينابيع الحارّة لمنطقة جيزان هي الكلوريدات ٣٤٦ ملجم/ لتر والبوتاسيوم ٣٤٧ ملجم/ لتر. لكن الأمونيا والنيترات وجدت بتراكيز لا تذكر. أما بقية العناصر مثل الحديد، والمنجنيز، والمغنيسيوم والزنك فوجدت بكميات قليلة.
- كِلَا الموقعين ظهر فيهما كل من الطحالب الخضراء المزرقة والطحالب الخضراء والطحالب الخضراء الخيطية.