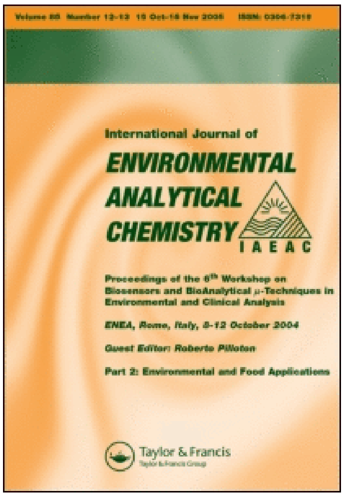

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ELEMENTAL AND GEOCHEMICAL ANALYSIS OF THE UMM-KHURISAN SPRING WATER (AL-HASA AREA, EASTERN PROVINCE, SAUDI ARABIA)

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The Umm-Khurisan spring is a small spring, located in the Al-Hasa area in the Eastern Province of Saudi Arabia.

The high concentrations of total hardness, total disolved solids, Cl^-, NO_3^- and F^-, and the high value of the electrical conductivity of the spring water are above the limits recommended by the World Health Organization standards with regard to potability. Concentrations, of other minor constituents are around these limits. Therefore, it is recommended that the Umm-Khurisan spring water should not be used for drinking purposes. The Umm-Kurisan water is a saline water with medium sodium hazard. Such water should be used only on soils of moderate to good permeability.

The Umm-Kurisan spring water probably is of meteoric origin of deep percolating water.

1. INTRODUCTION

The Umm-Khurisan spring is located in the Al-Hasa area, in the Eastern Province of Saudi Arabia. It is a small spring, situated within the Neogene formation, which is composed mainly of sandy marl, sandy limestone and marl. It is artesian in character. The Water reaches the spring through fractured beds of the underlining Neogene rocks. The Al-Hasa area is about 300 km from Riyadh, the capital of Saudi Arabia. It is about 130–160 m above sea level.[5] The Eastern Province belongs to the subtropic arid zone of the northern hemisphere, and the Al-Hasa area is considered to have a dry desert climate.[4] There are about 160 springs in the Al-Hasa area[1] which discharge about 10 m^3/sec. The water is used to grow dates, rice, alfalfa, and some vegetables in what is the largest irrigated area in Saudi Arabia.[2]

The Umm-Khurisan spring is about 2 km Southeast of Jabal Al Qarah, one of the most famous geological features in Al Hasa area. The Al Hasa area is one of the largest oases of the world. It is situated some 60 km inland of the Arabian Gulf coast, west of the sand desert of Al Jafurah.[5] Situated between the rock desert of the As Summan plateau in the east and sand dunes covering the adjoining plain in the west, the Al Hasa area depends upon the large karst springs at the eastern scarp of As Summan plateau. The springs of the northern Al Hasa area originate in a NW-striking joint system, parallel to the oil-bearing Ghawar anticline; the springs of the eastern Al Hasa area have their origin along a fault system crossing the anticline rectangularly (Figure 1). The spring area forms the surface of a heavily

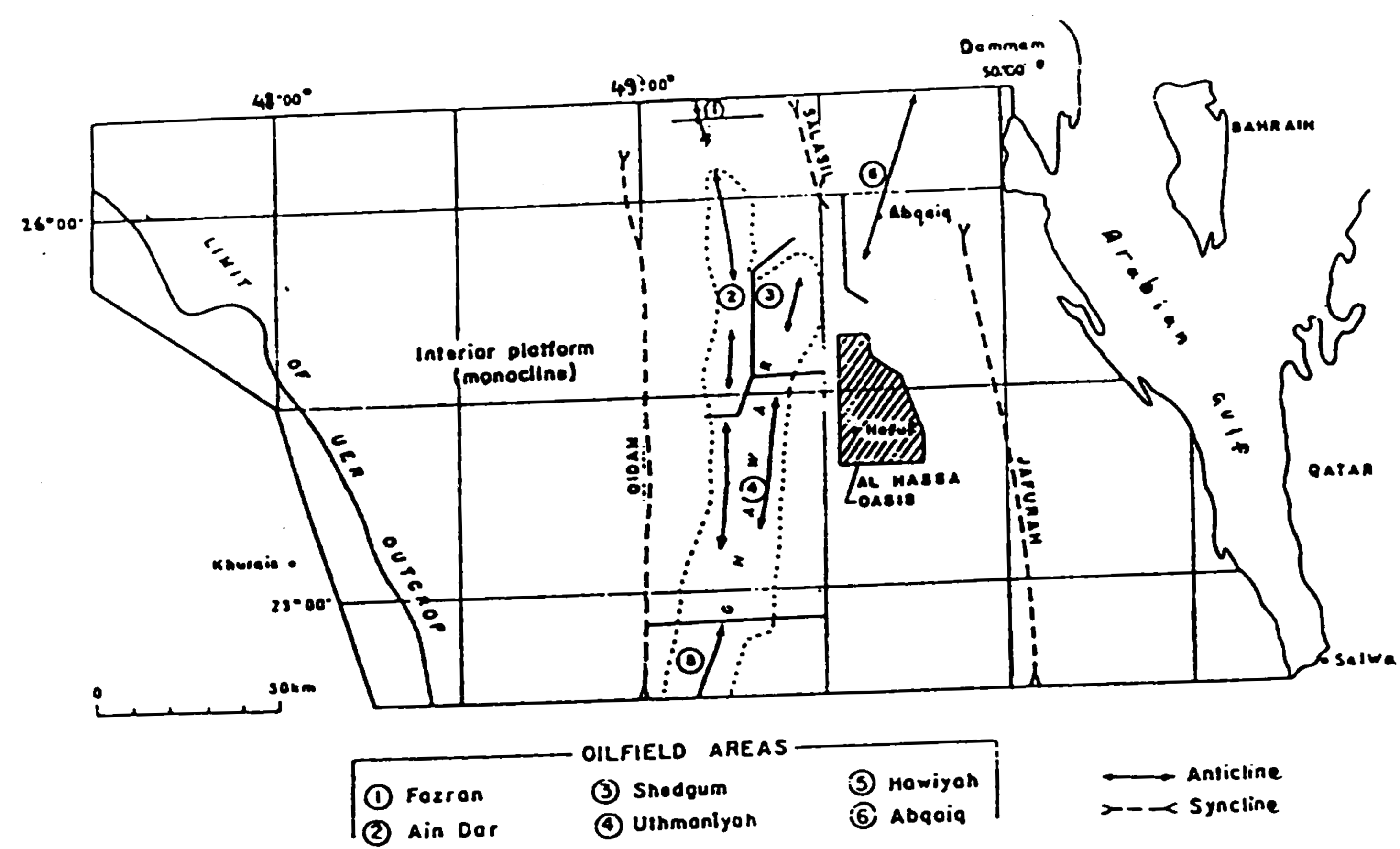

Figure 1 Map of the Al Hasa area and the surrounding oil fileds in the Eastern Province, Saudi Arabia.

karstified marly limestone of presumable Pliocene origin, and the springs discharge from vast solution caves and karst tubes.[5]

The geological features and characteristics of aquifers in the Al Hasa area are summarized in Table 1.[12] The Neogene formation is the major aquifer system feeding water to the Al Hasa springs.[3]

The purpose of this paper is to evaluate the water quality of Umm-Khurisan, and to look for its suitability for drinking and irrigation purposes.

MATERIAL AND METHODS

The geological features of the Al-Hasa area were studied during three field trips in 1986.

Representative water samples from the Umm-Khurisan spring were taken and stored in plastic bottles of 2 litres capacity. The bottles were previously cleaned with soap, and flushed with a preliminary water sample. In each case, five or six samples were taken separately and then mixed to get a representative sample for analysis.

The chemical analysis of the water samples, after their acidification with extra pure nitric acid (Aldrich, U.S.A.) for their preservation, were carried out at the Technical Service Laboratories (Toronto, Canada). The elemental concentrations of Na, K, Ca, Mg, Sb, Ba, B, Br, C, Cr, Cu, I, Pb, Mn, Ni, Si, Sn, V, and Zn were determined using ICP-AES.[8] Those of As and Se were determined by neutron activation analysis.[7,13] Other determinations including Cl^-, HCO_3^-, SO_4^{2-}, electrical conductivity, total hardness, total dissolved solids and pH value were carried out on the same samples, but without acidification, using the procedure suggested by Van Loon.[14]

Fluoride and nitrate were analyzed in the laboratory of the College of Pharmacy, King Saud University, within 24 h after water collection. The determination of fluoride and nitrate were made spectrophotometrically using phenoldisulphonic acid and Alizarin Red-S, Zirconium oxychloride reagents, respectively. Nitrate was determined at 410 mm and fluoride at 540 mm using a Carl–Zeiss spectrophotometer.

The temperature measurement of the spring water was carried out with a thermic probe. The value measured was about 34 °C.

RESULTS AND DISCUSSION

Table 2 shows the results of the chemical analysis for the Umm-Khurisan spring water. They are compared with the maximum permissible limits of the World Health Organization (W.H.O.) and National Academy of Science and National Academy of Engineering, NASNAE.[10]

The high value of T.D.S. may be caused by the high aridity of the area. The Umm-Khurisan spring water is almost neutral, highly conductive, and highly saline. The high concentrations of T.H., T.D.S., and the high value of E.C. are

Table 1 Stratigraphy of aquifers in Al Hasa area (Eastern Province, Saudi Arabia)

		Age	*Formation*	*Generalized lithologic description*	*Thickness (m)*
	Quaternary and Tertiary		*Superficial deposits*	*Gravel, sand and silt*	
CENOZOIC	Miocene and pliocene		Hofuf	Sandy marl and sandu limestone; subordinate calcareous sandstone. Local gravel beds in lower part.	95
CENOZOIC	Miocene and pliocene		Dam	Marl and shale; subordinate sandstone chalky limestone and coquina	91
CENOZOIC	Miocene and pliocene		Hadrukh	Calcareous, silty sandstone, sandy limestone; local chert	84
CENOZOIC	Eocene	Lutetian	Dammam	Limestone, dolomite, marl and shale	33
CENOZOIC	Eocene	Ypresian	Rus	Marl, chalky limestone and gypsum; common chert and geodal quartz in lower part. Dominantly anhydrite in subsurface	56
CENOZOIC	Pal-eocene	Thanetian Montian	Umm er Radhuma	Limestone, dolomitic limestone and dolomite	243
			?——?——Possibile disconformity	——?——?——	
MESOZOIC	Middle Cretaceous	Maestrichtian Campanian	Aruma	Limestone; subordinate and shale. Lower part grades to sandstone in northwestern and southern areas of outcrop.	142
MESOZOIC	Middle Cretaceous	Turonian Cenomanian	Wasia (Sakaka Sandstone of northwest Arabia)	Sandstone; subordinate shale, rare dolomite lenses	42

Table 2 Chemical analyses for the Umm-Khurisan spring water

*Ion or parameter***	*Concentration*	*Max. permissible limits*	
		W.H.O.	*NASNAE*
Na^+	600	—	—
K^+	44	—	—
Ca^{2+}	180	200	—
Mg^{2+}	110	150	—
Cl^+	984	600	250
SO_4^{2-}	202	400	250
HCO_3^-	427	—	—
NO_3^-	48	45	—
pH	7.1	6.5–9.2	—
T. H. (ppm) (as $CaCO_3$)	1680	—	—
E.C. (mhos/cm)	1735	—	—
T.D.S. (ppm)	3060	1500	1500

*All results for ions in ppm.
**T.H.,
E.C.,
T.D.S.,

above the limits recommended by the W.H.O.[16] with regard to potability. The chloride value is higher for this water than the maximum permissible limits for international standards.[10,16]

Table 3 shows the concentration of trace and minor elements. Concentrations of I, Pb, Mn, Mo, Ni, Sn, V, Zn, Sb, As, Ba, B, Br, Cd, Cr, Co, Cu and Su are within the maximum permissible limits suggested by the W.H.O. However, the NO_3^- and F^- values are higher for this water than the permissible limits of the W.H.O.[16] The relatively high nitrate concentrations suggest pollution from organix matter, such as agriculture fertilizers used near the spring, or to biological activity of notrogen fixation bacteria. The level of fluoride must not exceed the optimum level which is 0.5 – 1 ppm.[6,9] Water containing fluorides in concentration higher than 1.5 ppm is considered to be harmful to children. The water of this spring should not be used for drinking purposes.

The classification and use of this spring water can be tested by the sodium adsorption ratio (S.A.R.):

$$\text{S.A.R.} = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}} \quad (1)$$

where Na, Ca, and Mg represent the concentration in milliequivalent per litre.[15] It is evident that the Umm-Khurisan spring water can be classified as a so-called C_3-S_2 water, which means that it is saline water with a medium sodium hazard. Waters with SAR values in excess of 8 may cause a reduction in soil permeability by replacing the calcium ions adsorbed to the clay particles with sodium ions. The Umm-Khurisan water should be used only on soil of moderate to good

Table 3 Elemental concentration (ppm) for the water from the Umm-Khurisan spring

Elemants	*Concentration*	*Max. permissible limits*	
		W.H.O.	*NASNAE*
Antimony	≦0.04	—	—
Arsenic	≦0.01	0.05	0.01
Barium	0.01	—	1.0
Boron	0.68	—	—
Bromide	≦0.01	—	—
Cadimum	≦0.001	0.01	0.01
Chromium	≦0.003	—	0.50
Cobalt	≦0.01	—	—
Copper	≦0.01	—	—
Fluorine	1.60	0.8	—
Iodine	≦0.01	—	—
Lead	0.10	0.05	0.05
Maganese	≦0.003	0.50	—
Molybdneum	≦0.10	—	—
Nickel	≦0.05	—	—
Selenium	0.01	0.01	0.01
Silicon	34	—	—
Tin	0.07	—	—
Vanadium	≦0.01	—	—
Zinc	0.82	15	5

permeability. Regular leaching is often needed to prevent serious salinity. Plants of moderate to good salt tolerance should be selected in such cases.

The rather high value of silicon ions reflects the chemical composition of the aquifer rocks of the spring which belong to the Neogene formation.

The hydrochemical composition of Umm-Khurisan spring water indicates a continental genesis according to the equation:[11]

$$\frac{r(\text{Na-Cl})}{r\,SO_4} < 1 \qquad (2)$$

Where r denotes a constant equal to 1. The ratio $r(\text{Na-Cl})/r\,SO_4$ is usually higher than 1 for water of marine genesis. It is also of meteoric origin of deep percolating water according to the equation:[11]

$$\frac{r(K+Na)-Cl}{r\,SO_4} < 1 \qquad (3)$$

This indicates that water penetrated the rocks from above and percolated deeply in the rock beds through their pores, fissures and fractures. The Umm-Khurisan spring which is one of the Hasa springs has probably its origin in a fault system adjacent to the Ghawar Anticline.

Acknowledgement

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