

Spectroscopic Study of the Metallic Constituents in Some Underground Water in Al-Kaseem Area (Saudi Arabia)

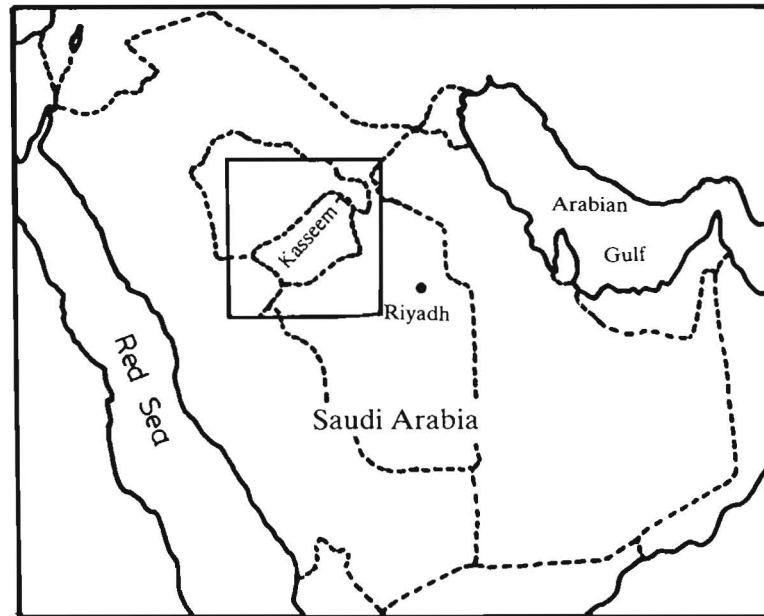
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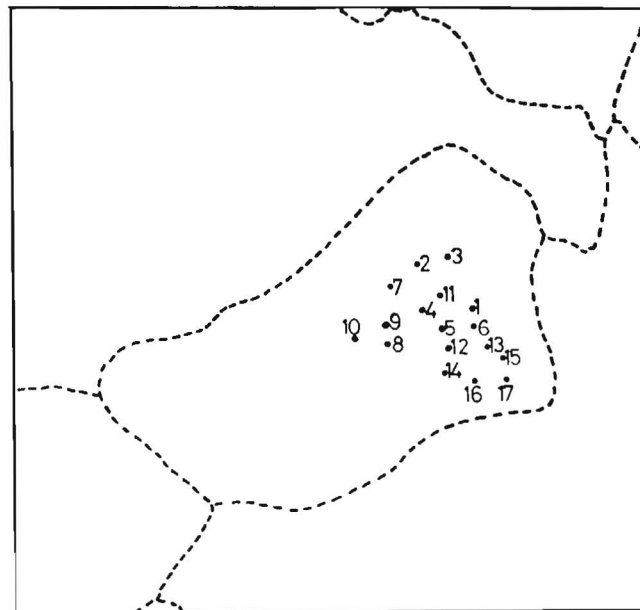
ABSTRACT. In this work both the atomic emission and atomic absorption spectroscopic techniques have been used for the determination of the metallic constituents in seventeen wells of underground water in Al-Kaseem area (Saudi Arabia), and eleven elements were detected. It is found that the major constituents elements in these resources are alkali elements, and the total transient elements constituents did not exceed 1mg/l. Also it is found that the quantity of alkali metals existing in the wells follow the sequence $\text{Na} > \text{Ca} > \text{Mg} > \text{K}$.

Underground water is one of the main sources of water supply for irrigation and domestic use in Al-Kaseem area. Consequently it is important to get information about the metallic constituents of such a vital source. However, detection of these metals require accurate and sensitive methods of analysis. In fact physical methods of analysis such as atomic emission and atomic absorption spectroscopy meet these requirements (Sachdev and West 1970).

In the last few years, several authors (Doneen 1958, Rhoades 1972, Christiansen *et al.* 1977, Ayers 1978, Shainberg and Oster 1978, Ayed and Mashhady 1982, Chan 1983, Zakai & Al-Zahrani 1983, Tebbutt 1984 and Tchobanoglous and Schroeder 1985) have used different methods for studying the salinity problem in underground water at different areas in Saudi Arabia. However detailed information about the metallic constituents have not yet been explored, therefore such a step is taken in this work. Both atomic emission and absorption spectroscopic techniques have been used for the evaluation of metals in seventeen underground water wells in Al-Kaseem area. The depths of these wells range between 100-200 m, and their location are shown in Map (1).



Map 1. (a): Location of Al-Kasseem area in Saudi Arabia.



Map 1. (b): Location of underground water resources in Al-Kasseem area used in this work.

Method of Analysis

Samples from the seventeen water wells were collected in such a way that each sample represents, to a maximum extent, the water in each well. Precautions were taken to preserve the samples from contamination. The pH values of the collected sample were measured and found to be near 7. The water samples were clear and did not contain suspension solids. Part of the water sample was subjected to evaporation at 105°C to extract dissolved solids (DS). The metals in these dissolved solids have been investigated qualitatively by using 3.4 meter Ebert grating Jarell Ash Spectrograph. The samples were mixed with free boron graphite in ratio 1:1 and arced in graphite electrode for 70 seconds at an electric current of 8 Amps with a gap width of 4 mm. Kodak photographic plates were used in the experiment. Developing and Fixing time were 5 minutes and 10 minutes respectively. Jarell Ash Comparator was used for detection of metals in the dissolved solids under investigation.

The instrument used for quantitative evaluation of metals in water was a single beam flame type burner and hollow cathods lamps models PMG III Zeiss Spectrophotometer. The condition of the instrument was optimized to have the best reproducible results. The error in the obtained results are estimated to be $\pm 10\%$. These conditions are given in Table (1).

Table 1. The condition of PMG III Zeiss Instrument for each metal under investigation

Metal	Wavelength (mm)	Slit width (mm)	Bandwidth	Acyteline
Na	589	0.05	0.4	75/55
K	766	0.05	6	75/55
Mg	885	0.05	0.3	75/55
Ca	422	0.05	1	75/55
Sr	467	0.02	0.54	75/55
Mn	280	0.05	0.28	75/55
Fe	249.3	0.05	0.18	75/55
Ni	232.3	0.06	0.15	75/55
Cu	324.7	0.02	0.28	75/55
Co	246.7	0.02	0.07	75/55
Zn	213.45	0.05	0.08	75/55

Stocks solutions of the detectable elements were prepared from their water salt. The stock solution consists of the most detectable elements, especially for alkali metals.

A working curve for each metal was established to determine the actual concentration of the metals in each sample. Samples that gave high concentrations were diluted to yield the linear portion of the working curve and then corrected by the dilution factor.

Results and Discussion

The dissolved solids (DS) for each water sample under investigation are given in column 2, Table (2). It can be seen that the (DS) contents vary from one sample to another. Since the (DS) is related to salinity (Al-Omran 1987, Train 1979 and Hashem 1990), one can conclude that most of these water wells have the salinity problem with exception of wells No. 5, 16 and 17, which have contents that lie in the permissible range of drinking water (International Standard for drinking water 1971, Greenberg *et al.* 1981 and Saudi Arabian Standard Organization 1984). However the samples from well No. 6, 13 and 15 are better as drinking water.

Table 2. The Total Alkali Metals (TAM) Contents and the Total Dissolved Solids (TDS) in Each Sample

Location	Dissolved Solids (DS) (mg/l)	Total Alkali Metals (TAM) (mg/l)
1	6080	2285
2	4691	1683
3	6530	2220
4	4000	1655
5	707	416
6	1257	639
7	3672	1132
8	5860	1651
9	3818	1284
10	5392	1943
11	5416	1399
12	2500	727
13	1250	419
14	7190	1855
15	1167	349
16	375	231
17	542	194

The quantitative determination of metallic constituents in the water samples is presented in Table (3). It can be seen that alkali metals are the dominant part in all samples under investigation. In Table (4) the ratios of Na/Ca, Na/Mg, Na/K, Ca/Mg, Ca/K and Mg/K are calculated. From these ratios it is deduced that these metals follow the sequence $Na > Ca > Mg > K$ in each sample except the ratio Na/Ca in sample No. 17 and Mg/K in sample No. 12. It is also found that these alkali metals vary from one well to another. This is probably due to the types of rock formations through which water flows and stored.

Table 3. Quantitative determination of the metallic constituents(mg/l) in the seventeen samples. (N.D.: not detected)

Location Metal	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Na	1200	975	1387.5	985.5	185	307	680	970	800	930	815	460	220	785	220	125	75
K	75.5	163.8	180	70	25	21.5	14	34	24	16.5	44.3	40	13	27	12.5	10	85
Mg	510	240	212.5	220	41.5	59.5	56	145	82.5	92	200	8.75	40.5	342.5	40.5	20	24.5
Ca	517.5	365	440	377.5	165	257.5	377.5	502.5	378	905	342.5	215	142.5	687.5	125	75	90
Sr	12.5	5.75	10.75	8	9.25	4.5	6.5	6.5	9.0	12.0	6.70	3.95	3.65	13.0	1.65	1.0	1.35
Mn	0.152	0.13	N.D.	0.043	0.05	0.087	0.087	0.18	0.109	0.109	0.065	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Ni	0.31	0.385	0.465	0.54	0.022	0.43	0.54	0.462	0.08	0.15	0.462	0.27	0.2	0.2	0.2	0.27	0.2
Cu	0.094	0.03	0.093	0.063	0.095	0.047	0.063	0.034	0.094	0.063	0.03	0.162	N.D.	0.27	0.108	N.D.	0.162
Fe	0.154	0.195	0.27	0.154	0.15	0.135	0.31	0.31	0.27	0.385	0.35	0.2	0.3	0.2	0.2	0.15	0.2
Co	0.2	0.15	0.10	0.05	0.63	0.2	N.D.	0.10	N.D.	0.25	0.10	N.D.	N.D.	0.26	N.D.	N.D.	0.26
Zr	0.058	0.043	0.029	0.039	0.23	0.050	0.05	0.01	0.07	0.096	N.D.	0.093	0.066	0.107	0.027	0.133	N.D.

Table 4. Relative ratios of alkali metals

Ratio of Location	Na/Ca	Na/Mg	Na/K	Ca/Mg	Ca/K	Mg/K
1	2.32	2.35	15.89	1.01	9.0	8.87
2	2.67	4.06	5.95	1.52	2.23	1.47
3	3.15	6.53	10.76	2.07	3.38	1.63
4	2.61	4.48	14.08	1.72	5.39	3.14
5	1.12	4.48	7.4	4.0	6.6	1.65
6	1.22	5.16	14.28	4.23	11.7	2.77
7	1.8	12.14	35.79	6.74	19.9	2.95
8	1.9	6.69	28.53	3.47	14.78	4.26
9	2.13	9.70	35.33	4.58	15.75	3.44
10	1.03	10.11	56.36	9.84	58.85	5.58
11	2.38	4.08	19.73	1.71	8.25	4.82
12	2.14	52.6	11.5	24.57	5.38	0.22
13	1.54	5.43	16.92	3.52	10.96	3.12
14	1.14	2.29	29.0	2.01	25.46	12.96
15	1.76	5.43	17.60	3.09	10.00	3.29
16	1.67	6.25	12.5	3.75	7.5	2.00
17	0.83	3.06	8.82	3.67	10.59	2.88

The total alkali metal contents as well as the dissolved solids in each sample are summarized in Table 2. It is interesting to note from table 2 that the total Alkali Metals (TAM) vary nearly in the same manner as DS in most of the samples. Sample No. 16 has the least TAM/TDS ratio. Plotting TAM against TDS a linear relation was obtained as shown in Fig. (1).

This means that as TAM contents increase TDS contents also increase. An empirical formula has been derived relating these quantities, using least square fit, which can be written as:

$$y = a + (b + \delta) x$$

where $a = 50$ mg/l, $b = 2.9$, $\delta = 0.5$, x and y represent the TAM and TDS contents respectively (Fig. (1)). Such relation would enable one to predict or at least estimate TDS contents if TAM is given or vis versa for other locations in nearby regions.

From the previous discussion one concludes that the dominant metals in these underground water wells are alkali ones. The water from most of the these wells must be treated before usage in irrigation or drinking to reduce their high salinity (Dalgano 1970, National Academy of Science (NAS) 1981 and Taymaz *et al.* 1984).

We hope such a study would lead for further expandable investigation and development of suitable techniques.

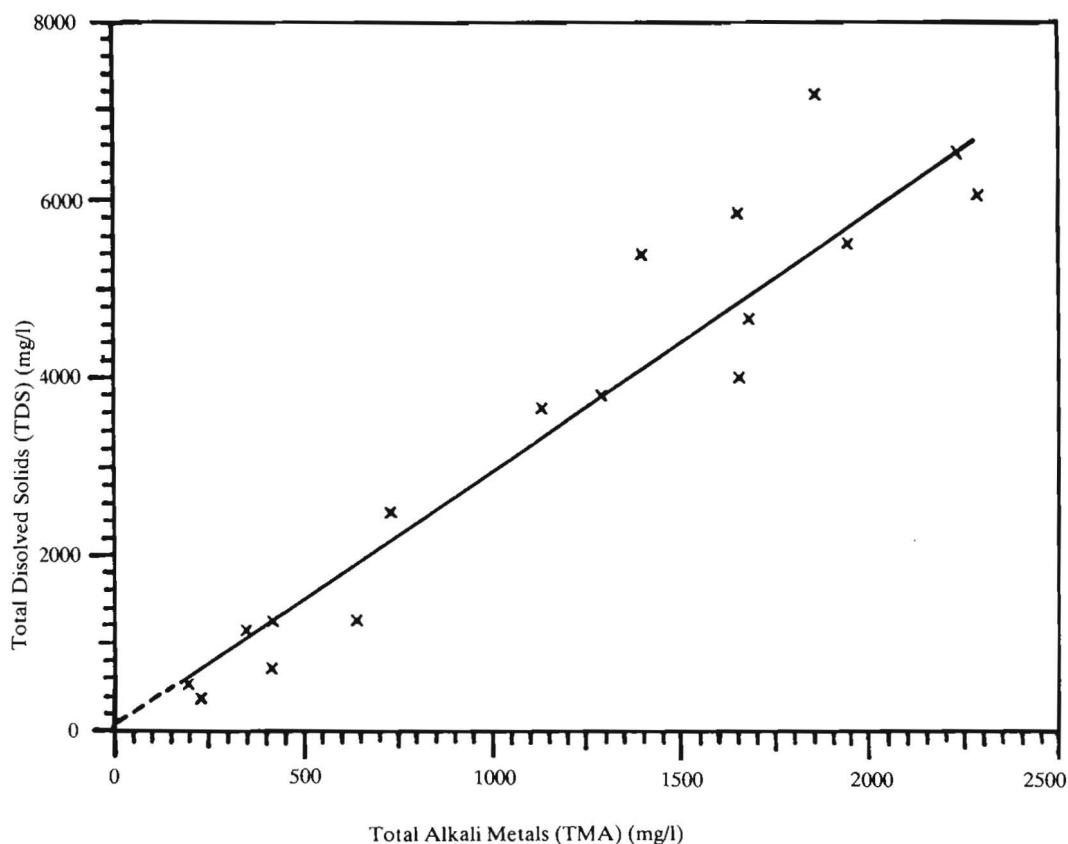


Fig. 1. The experimental data are plotted as crosses (x), and the solid line represents the theoretical fit.

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دراسة طيفية للمكونات المعدنية في المياه الجوفية بمنطقة القصيم

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تُعتبر المياه الجوفية في منطقة القصيم أهم مصدر لمياه الري والشرب. ولقد انصبَّ الاهتمام في السنوات السابقة على دراسة درجة ملوحة هذه المياه، إلا أن تعيين المكونات المعدنية لهذه المصادر يُعتبر أمراً حيوياً ليس فقط من الناحية الفيزيائية بل وكذلك من حيث الصحة.

إن تعيين مثل هذه المكونات يستلزم استخدام تقنيات وطرق غاية في الدقة، ولقد لجأنا لإجراء مثل هذا التحليل إلى استخدام الطرق الفيزيائية القائمة على التحليل الطيفي الانبعاثي والتحليل الطيفي الامتصاصي.

لقد تمَّ أخذ كافة الاحتياطات أثناء تجميع العينات بحيث تمثل المصدر المائي لأقصى درجة، كما تمَّ قياس pH مباشرة بعد أخذ العينات.

من نتائج التحليل أمكن استخلاص معادلة وصفية بين المواد الصلبة المحلولة (DS) والعناصر القلوية الكلية في العينات (TAM).

طريقة العمل

استخدم جهاز Jarell Ash Spectrograph لتحليل العينات بحيث تمَّ خلط العينات مع الجرافيت الخالي من البورون بنسبة ١ : ١ واستخدم الكترود جرافيتي للشرارة الكهربائية لزمّن تعريض ٧٠ ثانية وبتيار مقداره ٨ أمبير وعرض فتحة الشق ٤ مم، كما

استخدم جهاز المقارنة Jarell Ash Comparator وذلك لمعرفة نوعية العناصر في العينات، كما استخدم جهاز اللهب الامتصاصي، ولقد تمّ تثبيت منحني المعايرة لكل عينة، وذلك لتحديد تركيز كل عنصر في كل عينة.

نتيجة البحث والمناقشة

لقد وجد أن المواد الصلبة الذاتية تتغير في كل عينة عن الأخرى. ولما كان هناك ارتباط مباشر بين مكوّنات هذه العناصر ودرجة ملوحتها فإن بعض مصادر هذه العينات تعاني من مشكلة الملوحة. ومن نتائج التحليل وجد أن المواد القلوية هي المواد الغالبة في جميع العينات وأن العناصر القلوية تتبع التسلسل التالي: $Na > Ca > Mg > K$.

لقد لوحظ من الدراسات النظرية أن العناصر القلوية تتغير تغيراً طفيفاً تبعاً لتغير المواد الصلبة الذائبة، ومن الدراسات النظرية التي أُجريت أمكن إيجاد علاقة خطية تربط بين كمية العناصر القلوية وكمية المواد الذائبة.