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GROUNDWATER INVESTIGATION IN HADAT ASH SHAM AREA, WESTERN SAUDI ARABIA

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ABSTRACT

Hadat Ash Sham area is located in the western province of Saudi Arabia, and lies within arid region. The groundwater level of the alluvial aquifer in this area is declining continuously since 1989 with an average of 0.85 -3.15 m/year; this is due to over pumping from the wells. The quality of groundwater in this area is examined through fifteen water samples and found that rather a high salinity exists in most of the locations, and water in Hadat Ash Shm area can be used safely for drinking purposes only in four samples where the salinity is less than 1000 mg/l while the rest samples with high salinity need a prior treatment before it can be used safely for drinking. On the other hand the groundwater is found to be excellent for irrigation.

Keywords: Groundwater; Arid region; Salinity; Saudi Arabia.

INTRODUCTION

Groundwater is very important as the only source of water to supply human needs especially in arid regions like Saudi Arabia where there is no surface water and the rainfall is scarce, irregular and the evaporation rates are very high. Hence, the groundwater is a key resource for urban and rural supplies and it is considered as the only source, which can be supply domestic and agricultural needs in towns and villages. In Saudi Arabia, there are an increasing need of water as there is rapid growth of population and agricultural around the country.

Hadat Ash Sham is part of the Arabian Shield, which covers one-third of the Arabian Peninsula (Al-Sayari and Zotl,1978).

The study area is an habilitated area and located within the western part of Saudi Arabia and lies between longitude 39°40' and 39°45' E , and latitude 21°40' and 21°45' N. It is located about 160 km southeast of Jeddah city and about 50 km northwest of Makkah city and one can reach the study area by asphaltic roads (Fig.1).

MATERIALS AND METHODS

Fifteen groundwater samples were collected from the wells within this area. All water samples are taken while the wells were in operation to insure that the water is not contaminated from the surface and the samples are representative. The samples are collected in clean polyethylene bottles. Prior to collection, the sample bottles are rinsed thoroughly with the same water sample. The location of the water samples can be seen in Fig. 2. Some chemical parameters are measured at wellhead to give a convenient and rapid estimation as well as to provide control for the measurements in the laboratory. The chemical parameters, which are determined at the time of sampling, are Electrical Conductivity (EC) and Hydrogen Ion Concentration (P^H).

The chemical analysis of the previous water samples are carried out at the Faculty of Earth science laboratory, King Abdulaziz University where the major cations and anions are determined.

The groundwater quality within the area has been studied in the term of Total Dissolved Solid (TDS) and the major ionic constituents including Na, Ca, Mg, Cl, SO4 and HCO3 .

Geological Setting :

The study area is located within the western part of the Arabian Shield. Figure 3 shows a simple geological map for the area under study which is a part of Makkah Quadrangle map prepared by Moore and Al-Rehilie(1989). The study area includes the following rock types:

1- **Precambiran rocks:** These are assigned to Fayiadah Formation, which consists of felsic volcaniclastic rocks; subordinate andestic rhyolitic and basaltic lavas and andesitic volcaniclastic rocks.

2- **Precambrian intrusive rocks:** Belong to Shiwan Complex (Kwtn), and hornblende tonalite composition, and Hishash Complex (igd) which consists of granodiorite.

3- **Tertiary rocks:** These rocks are mainly belongs to two formations, namely, Hadat Ash Sham (Tsh) and Hammah Basalt (Trnhb). The former consists of pebbly sandstone, siltstone and it is exposed in the north and south of the study area, wheres the latter consist of alkalic olivine basalt.

4- **Quaternary deposits:** They cover extensive part of the study area and they are mainly derived from the weathering of the present rocks. The alluvium thicknesses are vary from place to another, and it does not exceed 4 m in the upper part of the study area while it increases towards the lower parts reaching up to 29 m. (Moor and Al-Rahilie,1989).

Climatic Conditions :

The study area has a typical desert climate where in the summer it is humid and hot while in winter season is moderate. This climate is characterized by low precipitation, high evapotranspiration, and low infiltration rates.

Due to lack of metrological data in the study area, it was necessary to look for the rainfall data from the nearest rainfall station. The recharge to the aquifer of Hadat Ash Shm area is from infiltration from rainfall. For this reason, the rainfall data is used at the Madrakah station, which is located north of the study area at 40 km distance. The rainfall data of this station form 1985 to 1995 are used and the average monthly rainfall is calculated and the results are shown in Figure 4. It is clear from this figure that the rainfall occurs during the whole year except in June. The high values of rainfall occurred during the winter season from October until January, and also in April.

Hydrogeology :

The aquifer in the study area is concentrated on the alluvium deposits, which cover most of the area, and the groundwater occurs under unconfined conditions. The alluvium deposits consist of alluvial sediments such as sands, silts, gravels, clay, etc. This aquifer is the principle source of water for all purposes in this area. The wells are of two types: hand dug wells which are fitted with some water lifting devices, such as buckets and electric- or diesel-powered pumps, while the others are bore wells which generally range 20 -70 m in depth. Hence, the dug wells tap shallow aquifer (<30m), and the bore wells are deeper (>30m).

The depths to water level are measured during this study at thirty wells (Fig 2), with unsaturated zone thickness that ranges between 16.66 and 58.47 m. b.g . The results of this investigation are given in Table 1. Al-Aqhbay,(1989) mentioned that the depth to water level in this area ranges between 5.5 and 17.5 m. Hence, one can get an idea about what had happened in this area during the last 13 years. It is clear that due to unmanaged drilling more wells are dug and hence more water is pumped from this aquifer. In addition to the absence or insufficient recharge to the aquifer, the water level drops continuously and most of the wells become dry as results of over pumping either to get water for domestic or agricultural uses. Under these circumstances local people dig wells to sell water to companies at cheapest rates.

As a result of mining the aquifer, many agricultural farms dried and the farmers in this area suffered extensively because they got loans from governmental departments. There are no incomes from their farms now. They decided to leave the agriculture sector and migrate to the nearest cities like Jeddah and Makkah.

The elevations of groundwater level are determined from the field measurements during this study and the results are presented in Figure 5 as groundwater contour map that describes the present groundwater conditions in Hadat Ash Sham Area. It is clear from this figure that the direction of groundwater movement is generally towards the north. A heavily pumped area is evidenced in the figure as depression in the water table in the eastern and western parts of the study area where there are concentration

of wells. On the other hand, the recharge, if any, is less than the discharge and this result in the drop of water table particularly in the southeast part of the area.

The amount of water pumped from these wells is not known because there is no timetable for the farmers for water pumping. However, one can expect extremely high values as witnessed by the water tankers that come each hour to get water from these wells.

The estimation of the amount of abstracted water from the thirty-four wells, which are investigated during this study by multiplying the average daily pumping rate at 0.2211 m3/sec for a period of 10 hours, gives a total discharge of water as 270601.92 m^3/day.

Also heavy pumping in the study area since 1989 has caused a wide water level drop between 0.85-3.15 m/y. For this reason it is necessary to conserve the groundwater source in this area and stop drilling new wells. Also the quantity of water that pumped from this aquifer must be controlled and restrictive decisions must be taken. Especially, the well owners must be controlle the water sales by tankers to the companies. So the groundwater in must thaaey will suffer from water shortage because the groundwater is not a renewable source.

Groundwater Quality :

The results of the chemical analyses of water samples are summarized in Table 1. The P^H of the samples range from 6.4 to 7.9, while the electrical conductivity generally ranges from 1010 to 7680 µS/cm (at 25°C).The total mineralization of the groundwater within the Hadat Ash Shm area varies from 634.90 mg/l to 46201.40 mg/l. It can be noticed here that the high mineralization may be from the prevailing arid conditions, where evaporation rates are very high causing an increase in concentration of salts in the soils. Figure 6 shows the variation in the quality of water in the study area in the form of Triliner (Piper) diagram. It can be seen from this figure that the dominant cations are calcium and magnesium while the chloride and sulfate are the dominant anions. In term of piper classification, the water in this area has 3 main sources of cations and anions which are:

(a) Alkaline earth exceeds alkalies,

(b) Strong acid exceeds alkalies, and,

(c) No one of the cations-anions pairs exceeds 50%.

The TDS is an important factor in the determination of water suitability (Driscoll,1987). From table 1 one can notice that the TDS in the study area can be divided into two categories.

1) less than 1000 mg/l (well numbers 4, 5,7 and 32) can be used for drinking purposes (World Health Organization,1993), and

2) More than 1000 mg/l , where water is not suitable for domestic use.

In locations with higher TDS values than WHO standard, they exploited and can be used for irrigation and other purposes.

On the other hand, the values of Sodium Absorption Ratio (SAR) range from 0.82 to 10.82, i.e low SAR in most of the wells in Hadat Ash Sham area. According to these values, the water can be used only in agricultural activities (U.S.Departement of Agricultral, 1954).

CONCLUSIONS AND RECOMMENDATIONS

Hadat Ash sham area is one of most areas in the western province that is characterized by relative high population. The groundwater is found in unconfined aquifer and the water table ranges from 16.66 to 58.47 m.b.g. Since 1989 the area suffered from continues dropping in the water table with an average ranging from 0.85 to 3.15 m/year. This is due to heavy pumping as a result of increasing of digging extremely high number of wells.

The groundwater has high salinity; the high salinity of the water is due to intensive evaporation of effluent surface irrigation water and to the interaction between water and the rocks through its way to the aquifer. The evaluation of groundwater in this area has been found that only four samples, with salinity less than 1000mg/l, can be used safely for drinking purposes. While the other water samples, having salinity more than 1000mg/l, need a pre treatments before it can be used.

Also from irrigation point of view the groundwater is found to have low SAR

and therefore it is suitable for irrigation only.

The use of groundwater in Hadat Ash Sham area must be controlled by minimizing the drilling of more wells in the area, and a network of observation wells must be installed in this area to montour the water level. Also periodic chemical analyses must be carried out to follow the change in the water quality in the area as a result of dropping the water level.

TABLE 1 .Chemical analysis of groundwater in the study area.

Well No.	Ca^{++} (mg/l)	Mg^{++} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	Cl^{-} (mg/l)	Hco_3^{-} (mg/l)	So_4^{--} (mg/l)	TDS (mg/l)	PH	EC (µS/cm)	SAR
1	270.46	236.85	1010.00	9.00	1690.24	210.43	1220.50	4647.48	7.1	4750.00	10.82
2	280.71	40.27	145.00	3.00	585.70	203.67	442.80	1701.15	7.2	1910.00	2.14
3	220.17	57.30	555.70	8.00	658.50	160.28	870.44	2530.39	7.5	2680.00	1.54
4	64.25	35.84	77.00	5.00	107.26	268.55	77.00	634.90	6.4	1520.00	1.91
5	65.28	28.47	136.00	2.00	158.82	235.65	240.48	866.70	7.3	1010.00	3.54
6	50.14	25.44	80.00	2.00	95.32	210.42	240.18	703.50	6.6	1500.00	2.30
7	226.54	60.68	155.00	4.00	470.15	175.25	448.40	1540.02	7.0	1510.00	2.36
8	145.25	17.58	145.00	7.00	300.34	295.25	270.32	1180.74	7.0	1588.00	3.03
20	760.60	510.45	1080.00	10.00	2820.20	140.40	2033.80	7355.45	7.8	7680.00	7.43
21	680.50	469.15	790.00	13.00	2680.65	177.40	1390.70	6201.40	7.3	5790.00	5.71
23	580.70	410.10	625.00	16.00	2040.30	187.30	1410.20	5269.60	7.6	4880.00	4.85
26	282.70	90.43	110.00	4.00	515.16	222.17	600.60	1825.06	7.6	3210.00	1.46
28	325.42	80.15	64.00	5.00	740.35	130.76	525.50	1871.18	7.5	3020.00	0.82
31	80.25	78.50	58.00	7.00	94.62	108.35	353.82	780.54	7.9	1000.00	1.10
32	227.45	62.52	160.00	4.00	480.80	176.35	446.80	1557.92	7.8	1500.00	2.42

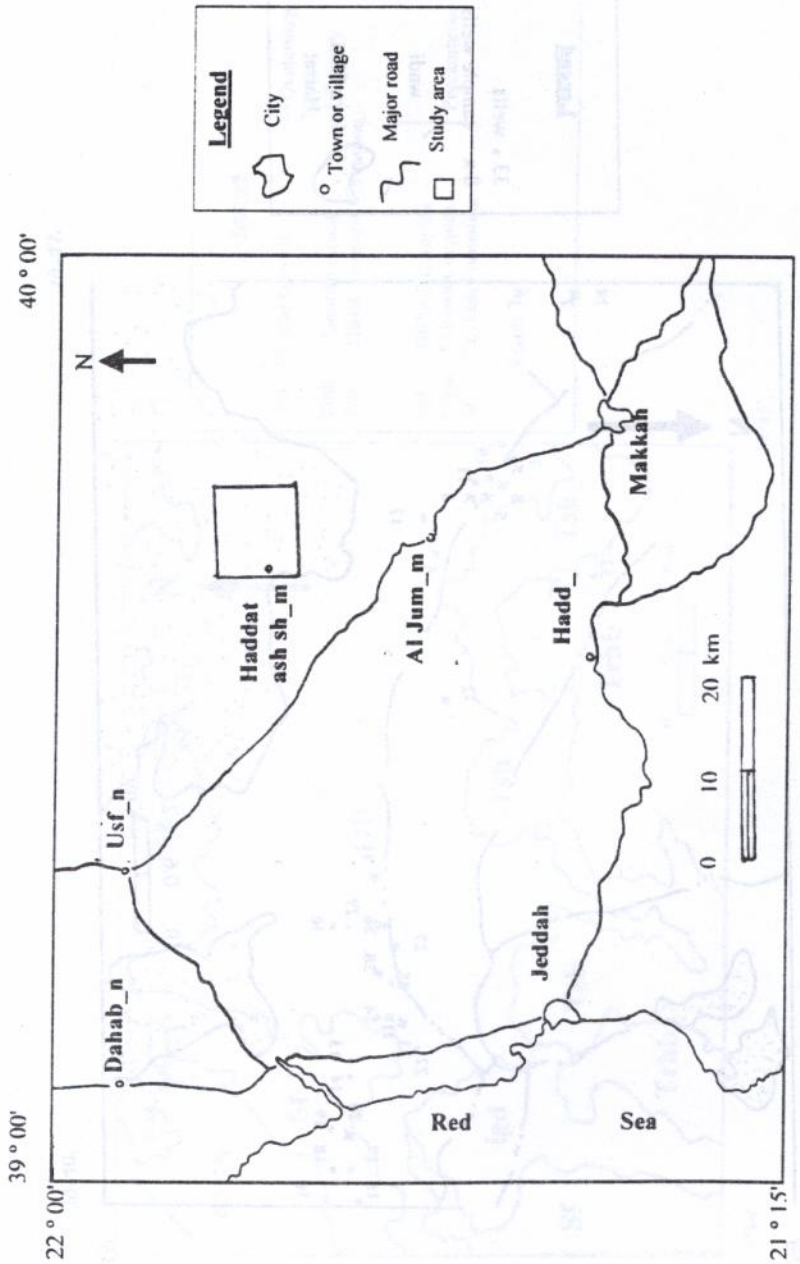

Figure 1 : Location map of the study area.

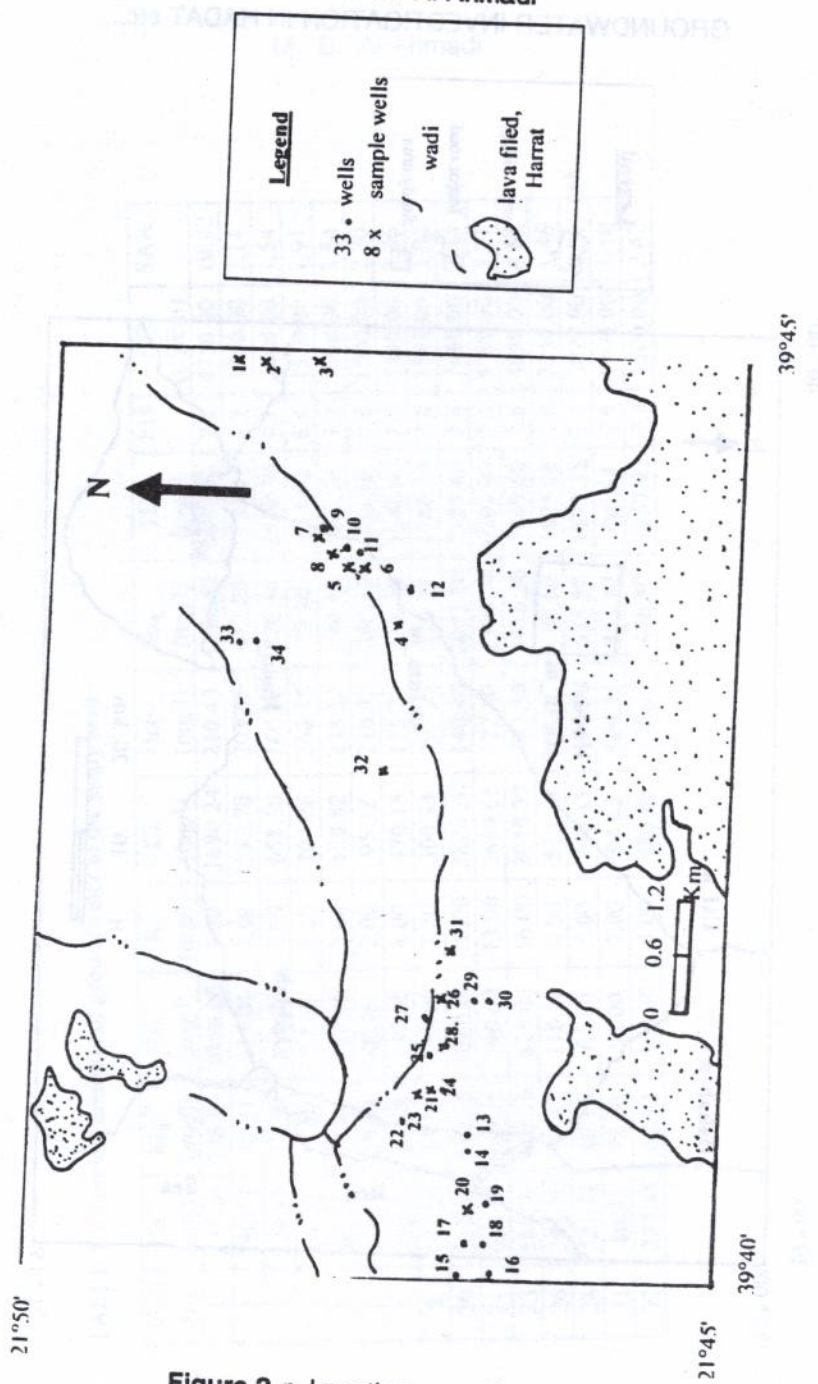

Figure 2 : Location map of the wells.

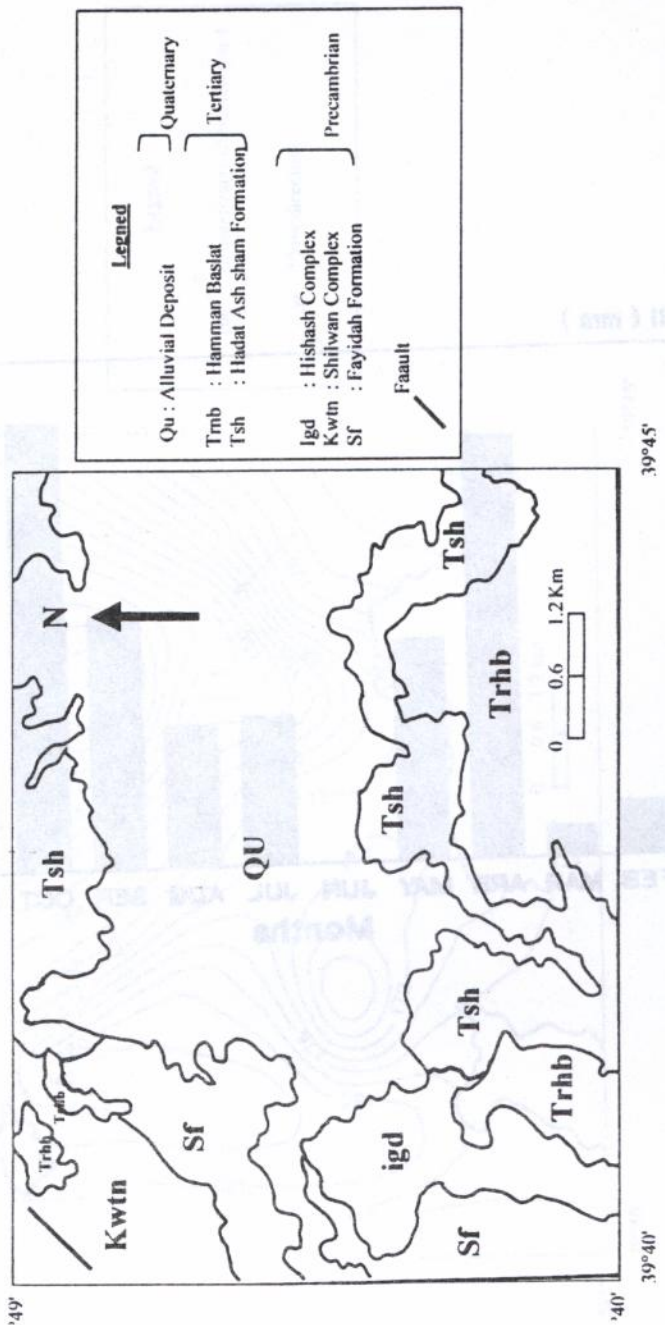

Figure 3 : A simplified geologic map of the study area.

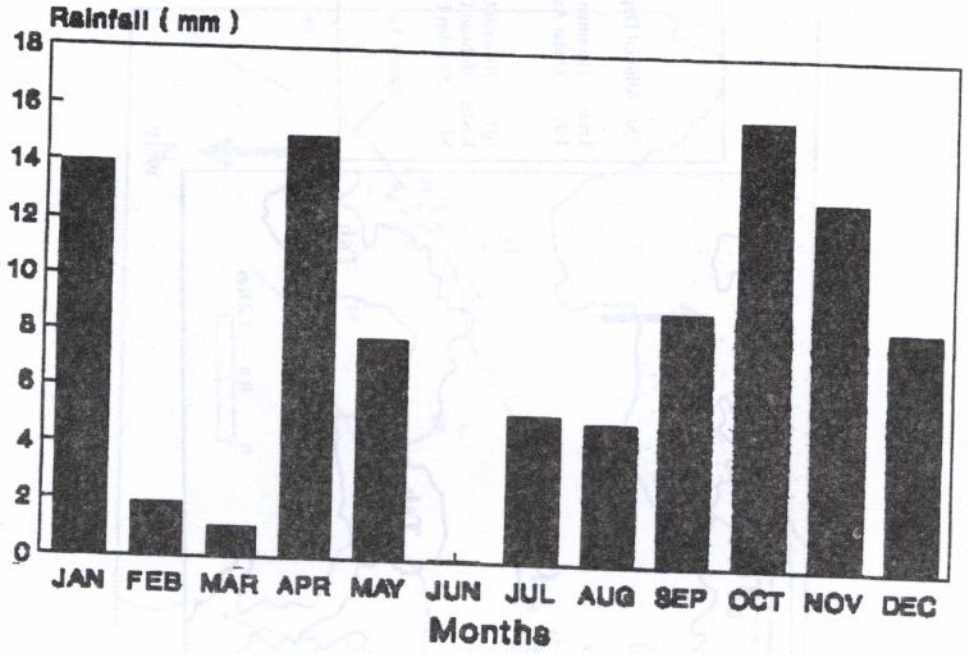

Figure 4 : Monthly average of rainfall in Madrakah station (1985 - 1995).

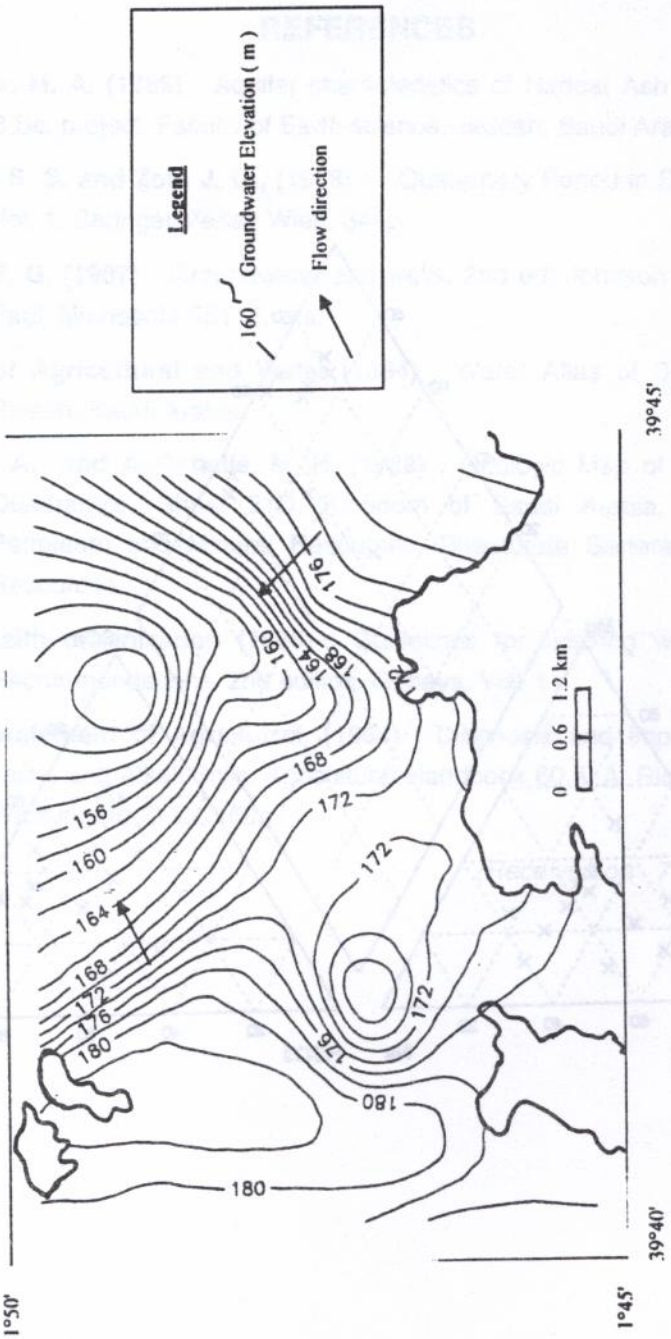

Figure 5 : Water table contour map of groundwater in the study area.

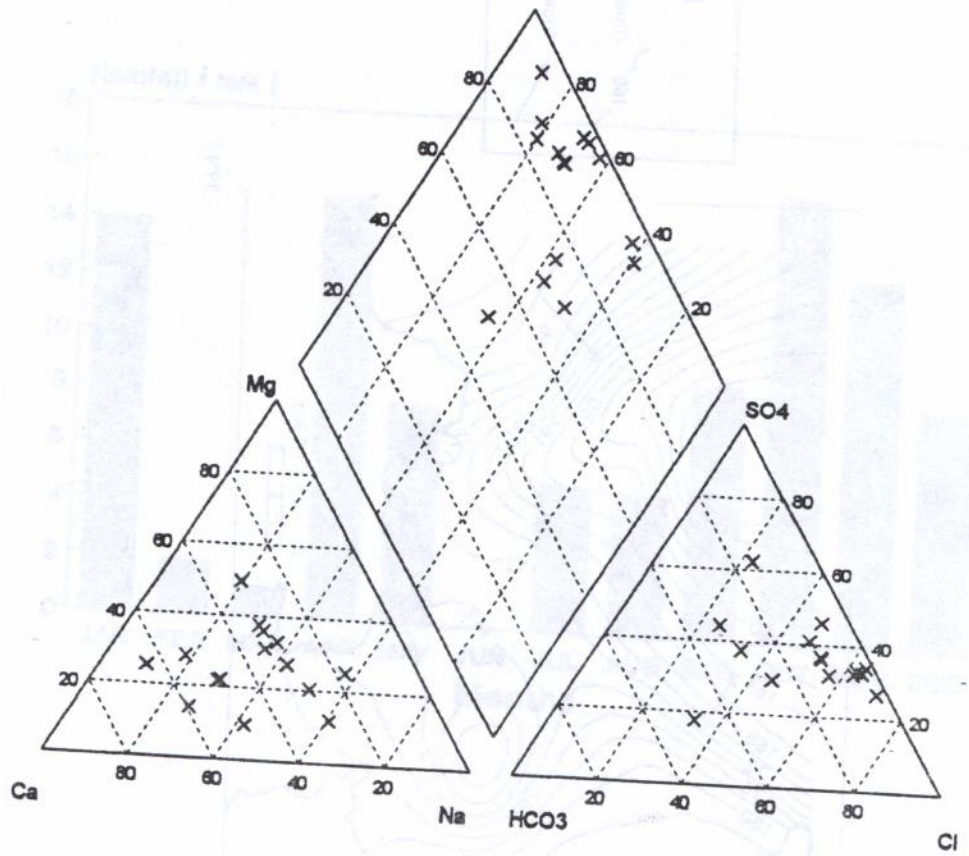

Figure 6 : Triliner (Piper) diagram of water analysis of Hadat Ash Shm area.

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الملخص العربى
دراسات عن المياه الأرضية بمنطقة هادات الشام وغرب المملكة العربية السعودية

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جـدة - المملكـة العربيـة السـعوديـة

تقع هادات الشام فى الجهة الغربية من المملكة العربية السعودية وتتميز عموماً بمناخ قارى، ووجد أن منسوب المياه الأرضى فى الخزان الفتاتى الصخرى فى هذه المنطقة يتدهور بصفة مستمرة منذ عام ١٩٨٩ بمعدل ٨ر٠ و ١٥ر٣م/سنة، وذلك نتيجه السحب المستمر من آبار المنطقة ومن خلال التحليل الكيماوى لعدد ١٥ عينة مياه من الآبار وجد أن المياه لها ملوحة عالية بصفة عامة ولكن يوجد أربعة آبار منها تصلح مياهها للشرب، حيث أن درجة ملوحتها أقل من ١٠٠٠ ملجم / اللتر فى حين تزيد عن ذلك فى المناطق الأخرى وتحتاج مياه الآبار الأخيرة إلى معالجة مسبقة حتى يمكن إستخدامها بأمان لأغراض الشرب والرى.