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Evaluation of Ground Water Quality in Wadi Al-Yamaniyah Saudi Arabia

Abdulghaffar Said Bazuhair and Abobader Alkaff

Hydrogeology Department, Faculty of Earth Sciences, King Abdulaziz University, Jeddah, Saudi Arabia

ABSTRACT. In an area, such as the Wadi Al-Yamaniyah, neighbouring the Holy City of Makkah and also in the recreational city of the Kingdom, Taif, the study of the ground water is important. The objective of this paper is to evaluate the quality of Wadi Al-Yamaniyah ground water over a two year period ground water was analysed on two different occasions.

The water analyses of thirty six samples in 1987 show that the salinity is low. Statistical and classical methods for interpretation of the water quality data of the years 1981 and 1987, however, indicate that the quality changed significantly. The waters have became low in ion content and have improved for domestic and agriculture utilities. On the other hand, during 1987 compared to 1981 the average water table drop was seven meters. The conclusion is that the aquifer thas been cleaned of salts which were present before the year 1972, as after that year the discharge from the wells began. It is concluded that the water from Al-Yamaniyah aquifer is expected to be of good quality and becomes important for use in the cities of Makkah and Taif.

Wadi Al-Yamaniyah is located in the western part of Saudi Arabia. The catchment area occupies about 620 Km^2 and lies within the Arabian shield and coastal plain (Fig. 1). Despite the fact that this area is close to the Holy City of Makkah as well as to the recreational city of Taif, water study was disregarded.

Bazuhair (1981) was the first to make a comprehensive hydrogeological study of Wadi Al-Yamaniyah. He reported that the wadi aquifer is unconfined and characterized by typical alluvial valley fill deposits. The main wadi and its tributaries remain dry throughout most of the year but during seasonal rainfall when some precipitation infiltrates down through fissures and fractures to the bed rock and porous mantle of the alluvial soil. Bazuhair notes that, the abstraction from the ground water needs better management. Bashir *et al,* 1986 was reported that, the quantities of the discharged water, from thirty six private large diameter wells, were 1.379×10^6 m^3 and 1.645×10^6 m^3 for the years 1978 and 1979 respectively. This study shows and increase of up to 2.5 times that of the quantity discharged in the year 1979.

The main aspect of the present study is to make an evaluation for the ground water on regional basis, linked with the already available hydrochemistry data.

Bazuhair (1981) analysed thiry six water samples for the main chemical constituents Ca^{+2}, Na^{+1}, K^{+1}, Mg^{2+}, HCO_3^{-1}, CI^{-1}, and SO_4^{-1} (Table 1). Recently, the authors collected an equivalent almost the same number of water samples from identical locations and performed similar analyses, (Table 2). The accuracy of the chemical analyses of samples has been checked by calculating the cation-anion balance in terms of milliequivalents per litre.

Geomorphological and Geological Condition.

The relief shows an elevation rise from west to east *i.e.*, the area upstream of wadi Al-Yamaniyah is surrounded by height mountains up to 1000 m a.m.S.L, whereas at the midstream the elevation does not exceed more than 600 m. The main wadi and it's tributary mostly follow fracture zones. The calculated values of the drainage density is $D_d = 2 \times 10^{-1}$ Km^{-1} which indicates that the region has low relief and permeable subsoil. In addition, the wadi is of fairly narrow width and has long course. Also, the valley system is mainly ephemeral. The main land features in the area are dissected by mountains with steep sided slopes ranging up to 35-40°. Furthermore, conical to sub-conical and convex crested hills interfere with flat floor of the wadies. Wadi side alluvial terraces, alluvial fans and cones, form typical land features in the area.

Geological studies have been carried out in the area by Brown *et al.*, (1962). They classified the rocks into two main units, an older metamorphic unit and a younger is plutonic unit (Fig. 1). Both units are of precambrian age and are cut by acidic and basic dikes of variable ages. The metamorphic rocks are represented by amphibolite schist and gneiss, while the plutonic rocks are mainly diorite and granite. The recent alluvial deposits of the quaternary age consist of gravel, sand, silty sand and clay. They vary in thickness from 25 m to 20 m upstream through downstream along the wadi. The quaternay deposits include weathered material rounded by the effect of transport by water and generally exhibit an intergranular flow.

A complex fracturing, fissuring and joint system, has rendered the crystalline rocks permeable at the flanks of the wadi. Natural replenishment takes place from

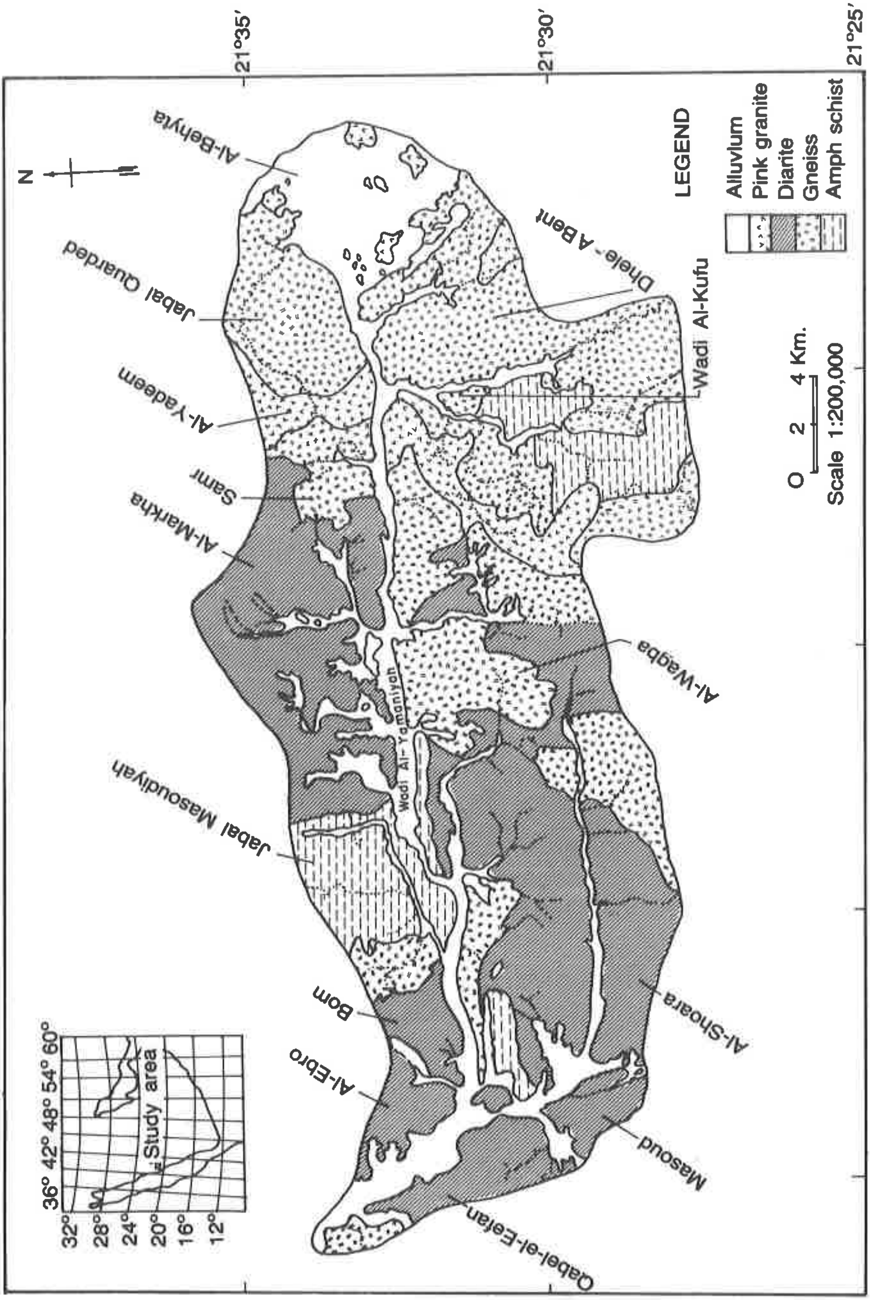

Fig. 1. Geological map of wadi Al-Yamaniyah area

the local, but intensive, rainfall of short duration through complex fissures and joint systems.

Hydrological Considerations

The weather in Al-Yamaniyah develops in a transitional zone between the

Table 1. The water chemical analysis of the year 1981

Well No.	pH	E.C	TDS	Ca	Mg	Na	K	HCO_3	SO_4	Cl	Ca	Mg	Na
				Concentration in mg/L							Concentration		
1	7.2	1300	845	92.91	26.50	103.90	5.81	236.3	114.6	159.6	4.60	2.20	4.5
2	6.2	1300	845	89.34	28.95	92.73	8.30	247.4	123.9	173.8	4.50	2.40	4.1
3	7.0	900	585	100.0	25.93	85.31	14.94	325.1	93.8	145.4	5.00	2.14	3.7
4	6.9	1000	650	72.90	19.30	74.18	5.40	223.6	88.1	120.6	3.64	1.60	3.2
5	6.8	950	617.5	76.60	19.30	89.60	7.06	218.9	88.1	124.1	3.92	1.60	3.87
7	7.0	800	520	75.04	15.92	70.49	5.00	209.4	67.1	120.6	3.74	1.32	3.10
8	6.9	800	520	107.20	9.70	43.00	10.38	236.5	112.8	95.7	5.38	0.80	1.90
9	6.95	1300	845	103.63	25.33	102.40	5.65	304.5	109.1	163.1	5.17	2.10	4.45
10	7.0	1100	715	72.90	23.52	66.76	5.00	153.8	93.8	145.4	3.64	1.95	2.90
13	7.0	2700	1890	278.73	55.79	118.68	3.32	233.1	230.9	536.7	13.90	4.60	5.16
15	6.95	2700	1890	214.41	49.50	174.30	4.15	217.3	251.5	468.1	10.70	4.10	7.60
16	7.00	1700	1105	185.50	21.10	60.80	5.19	217.3	129.7	241.0	9.27	1.74	2.91
17	7.5	2300	1610	214.41	56.70	196.60	3.32	198.3	298.4	516.7	10.70	4.68	8.55
18	8.0	2900	2030	214.41	58.50	207.70	9.96	233.1	242.4	564.0	10.70	4.80	9.04
19	7.8	3400	2380	285.90	156.96	96.00	6.23	195.1	1016.3	195.1	14.30	12.96	11.30
20	7.0	2200	1540	164.40	44.60	333.80	3.74	147.5	685.6	147.5	8.20	3.70	14.50
21	7.8	3400	2380	428.80	108.60	315.30	2.50	142.7	1119.0	142.7	21.40	8.97	13.70
22	7.8	3900	2730	271.60	20.50	185.50	9.55	212.5	790.8	212.5	13.55	1.70	18.10
23	7.7	3800	2660	273.30	48.20	313.00	2.10	212.5	564.3	498.0	11.60	3.98	13.60
24	7.4	2900	2030	193.00	48.20	341.20	3.74	249.0	419.8	556.7	9.60	3.98	14.84
25	7.8	900	585	128.60	18.10	37.50	6.23	315.6	63.8	113.5	6.41	1.50	1.63
26	7.8	800	520	111.50	13.30	51.90	2.10	258.5	87.7	103.5	5.65	1.10	2.36
27	7.9	700	455	135.80	12.20	44.50	2.91	230.0	65.9	167.0	6.80	1.00	1.94
28	7.6	800	520	121.50	11.50	40.10	8.30	250.1	78.6	113.0	6.10	0.95	1.74
29	7.7	950	617.5	121.50	10.90	41.50	7.30	236.5	67.91	122.0	6.10	0.90	1.81
30	8.0	7400	5180	428.80	96.50	1039.5	7.10	231.6	959.0	1808.0	21.40	7.98	45.20
31	7.9	10000	7000	796.90	150.80	806.0	33.21	158.6	1073.5	2240.0	39.80	12.50	35.10
32	7.4	700	455	107.20	15.70	48.20	2.10	231.6	35.4	151.6	9.35	1.29	2.10
33	7.6	800	520	121.50	15.70	55.60	5.40	178.1	67.5	108.0	6.06	1.30	2.42
34	7.5	900	585	114.40	16.60	61.00	14.50	271.3	93.4	131.2	5.71	1.37	2.65
35	7.5	1100	715	128.60	25.30	66.80	12.50	169.7	108.7	237.0	6.42	2.10	2.91
36	7.5	850	5525	111.50	12.10	48.20	5.80	169.4	89.7	147.0	5.56	1.00	2.10
37	7.7	950	617.5	142.90	31.40	48.20	6.60	168.1	94.3	258.0	7.13	2.59	2.10
38	7.7	3900	2730	393.10	75.40	401.0	14.90	410.8	717.0	780.0	19.60	6.23	17.44
39	7.8	3900	2730	375.70	75.40	723.3	5.40	758.9	672.0	1351.0	18.70	6.23	31.50
40	7.6	10000	7000	893.40	187.00	927.3	13.70	119.0	1258.0	2571.0	44.60	15.50	40.30
41	7.6	500	325	88.60	6.00	37.1	5.00	225.1	76.6	225.1	4.40	0.490	1.61

Monsoon and Mediterranean regions. It is largely modified by the Red Sea and the shield escarpment surrounding the area.

Due to the absence of regular climatological stations in the study area, reliable records of climatological variables are difficult to obtain for further processing.

In epm					Ions Percentage						TH in	
K	HCO_3	SO_4	Cl	Ca	Mg	Na	K	HCO_3	SO_4	Cl	ppm	SAR
0.15	3.87	2.37	4.50	40.3	19.10	39.3	1.3	35.90	21.97	41.7	341.20	1.220
0.21	4.10	2.58	4.90	40.2	21.60	36.3	1.9	35.40	22.28	42.3	342.21	2.182
0.38	5.33	1.95	4.10	44.5	19.10	33.1	3.4	46.80	17.20	36.1	356.40	1.960
0.14	3.66	1.83	3.40	42.3	18.50	37.5	1.6	41.20	20.60	38.2	261.45	1.995
0.18	3.60	1.83	3.50	40.9	16.70	40.5	1.9	40.20	20.60	39.2	275.73	2.331
0.13	3.43	1.40	3.40	45.1	15.90	37.4	1.5	41.70	16.97	41.6	252.88	1.950
0.27	3.87	2.35	2.70	64.7	9.60	22.8	3.2	43.40	26.40	30.3	306.52	1.100
0.15	4.99	2.27	4.60	43.8	17.80	37.7	1.2	42.30	19.24	38.98	362.99	1.214
0.13	2.52	1.95	4.11	42.2	22.40	33.67	1.5	29.30	22.70	47.8	278.82	1.700
0.09	3.82	4.81	15.14	58.5	19.35	21.7	0.35	16.10	20.20	63.7	925.56	1.700
0.11	3.56	5.23	13.20	47.6	18.15	33.73	0.5	16.17	23.80	60.0	738.87	2.790
0.133	4.45	2.70	6.85	65.9	12.40	20.7	0.95	31.80	19.30	48.9	550.97	1.240
0.09	3.25	6.20	14.60	44.5	19.50	35.6	0.35	13.53	25.90	60.5	768.66	3.100
0.26	3.82	5.10	15.00	43.1	19.30	36.4	1.10	15.40	20.50	60.4	776.11	3.247
0.16	3.20	6.80	28.70	36.9	33.50	29.2	0.41	8.27	17.60	74.2	1359.12	3.061
0.10	2.42	4.80	19.30	30.95	13.95	54.7	0.36	9.10	18.10	72.7	594.00	4.200
0.64	2.34	10.20	31.60	48.50	20.30	31.0	0.145	5.30	23.10	71.5	1517.60	3.520
0.24	3.48	7.90	22.30	40.30	5.10	53.9	0.73	10.40	23.50	66.4	762.54	6.550
0.053	3.48	11.75	14.00	39.66	13.61	46.6	0.18	11.62	40.20	47.9	778.40	4.880
0.096	4.10	8.74	15.70	33.63	13.94	51.98	0.34	14.10	30.60	54.99	680.30	5.695
0.160	5.17	1.33	3.20	66.10	15.50	16.8	1.64	53.30	13.71	32.99	395.60	6.820
0.053	4.24	1.83	2.92	61.92	12.25	25.2	0.59	47.20	20.40	32.5	333.15	1.830
0.074	3.70	1.37	4.71	69.20	10.21	19.8	0.76	37.82	14.10	48.2	389.30	0.984
0.210	4.10	1.64	3.20	67.6	10.60	19.5	2.34	45.86	18.30	35.8	350.71	0.932
0.190	3.88	1.41	3.46	67.6	10.01	20.2	2.12	44.30	16.10	39.5	98.54	0.970
0.181	3.80	19.97	51.00	28.6	10.69	60.5	0.24	5.08	26.70	68.2	1467.80	11.800
0.850	2.60	22.35	63.20	45.1	14.18	39.8	0.96	2.95	25.30	71.7	2610.40	6.866
0.053	3.80	0.73	4.30	60.8	14.75	23.9	0.60	43.18	8.30	48.6	332.30	1.152
0.140	2.92	1.41	5.57	61.1	13.10	24.4	1.39	29.40	14.20	56.15	367.99	0.657
0.370	4.45	1.95	3.70	56.5	13.56	26.2	3.66	44.10	19.31	36.63	353.96	1.410
0.320	2.80	2.26	6.67	54.6	17.80	24.8	2.70	23.85	19.30	56.8	425.22	1.410
0.150	2.80	1.87	4.13	63.15	11.35	23.8	1.68	31.78	21.20	46.9	328.21	1.590
0.690	2.75	1.96	7.30	59.4	21.63	17.5	1.41	22.92	16.30	60.3	486.03	0.950
0.381	6.73	14.93	22.00	44.9	14.30	39.9	0.872	15.40	34.20	50.4	1291.84	4.850
0.140	12.44	14.00	30.12	33.1	11.03	55.6	0.244	21.99	24.80	53.3	1247.15	8.910
0.350	1.95	26.20	72.53	44.3	15.35	40.1	0.350	1.94	26.10	72.0	3000.30	7.360
0.128	3.69	0.81	2.16	66.97	7.50	24.45	1.940	55.91	12.30	32.7	245.90	1.030

Precipitation in the area is irregular, unpredictable and long dry periods are common. Rainfall in Al-Yamaniyah is of two types namely continental in winter and monsoonal in summer. The annual rainfall exceeds 300 mm in the mountainous area, whereas in the wadi it averages between 50 to 100 mm. The

Table 2. The water chemical analysis of the year 1987

	Concentration in mg/L											Concentration	
Well No.	pH	E.C	T.D.S	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	HCO_3^{-1}	SO_4^{-1}	Cl^{-1}	Ca^{+2}	Mg^{+2}	Na^{+1}
4A	7.9	1323	926.1	118.63	43.78	107.82	5	431.97	109.70	191.42	5.92	3.6	4.69
4B	8.5	–	–	126.63	37.94	104.83	5	347.77	111.54	223.30	6.32	3.1	4.56
5	7.8	1500	1050.0	141.08	48.64	167.82	6	9.62	116.07	239.28	7.04	4.0	7.30
7	8.1	1110	777.0	105.81	36.97	109.66	5	163.69	82.32	143.57	5.28	3.04	4.77
8	8.0	1108	775.6	91.38	36.00	99.77	5	347.77	95.08	159.52	4.56	2.96	4.34
9	8.05	1364	954.8	113.82	45.72	154.49	5	463.69	114.72	199.40	5.68	3.76	5.85
10	7.95	787	350.9	60.92	28.21	103.45	4	347.77	59.86	119.64	3.04	2.32	4.50
11	7.85	2380	1666.0	169.95	102.14	151.72	3	440.51	228.43	422.72	8.48	8.40	6.60
13	7.70	5010	3507.0	351.10	163.14	218.86	4	347.77	198.80	116.63	17.52	13.42	9.52
14	8.15	807	564.9	80.16	24.32	103.45	2	431.97	55.15	95.71	4.00	2.00	4.50
16	8.10	1435	100450	141.08	38.91	44.83	7	347.77	88.08	145.47	7.04	3.20	1.95
17	8.00	825	577.5	78.55	35.02	71.27	4	370.95	60.09	95.71	3.92	2.88	3.10
19	8.15	914	639.8	73.74	36.00	97.25	5	370.95	70.38	129.74	3.68	2.96	4.23
22	8.0	1028	719.6	104.20	27.24	99.09	5	431.97	97.55	143.57	5.12	2.24	4.31
23	8.35	1034	723.8	92.98	36.97	90.58	6	394.14	65.44	143.57	4.64	3.04	3.94
26	8.25	884	618.8	76.98	29.18	108.05	5	394.14	59.68	129.74	3.84	2.40	4.70
27	8.15	836	585.2	81.76	24.32	109.20	5	431.97	54.74	111.66	4.08	2.00	4.75
28	8.25	913	639.1	83.36	31.13	95.40	5	347.77	68.32	143.57	4.16	2.56	4.15
29A	8.1	1749	1224.3	160.32	10.04	81.84	7	394.14	165.87	271.18	8.00	5.76	3.56
28B	8.15	–	–	168.33	56.42	94.72	7	359.36	176.58	283.59	8.40	4.64	4.12
30	8.2	963	674.1	92.98	27.24	85.75	5	324.58	72.14	143.56	4.64	2.24	3.73
31	8.35	928	649.6	83.36	34.05	84.83	5	247.77	76.15	127.61	4.16	1.80	3.69
35	8.1	968	627.6	96.19	23.35	96.70	5	324.58	90.14	143.56	4.80	1.92	4.21
37	8.15	970	679.0	76.95	35.02	94.26	6	347.77	87.67	127.61	3.84	2.88	4.10
38	8.3	928	649.6	83.36	33.08	82.76	5	324.58	86.85	127.61	4.16	2.72	3.60
39	8.1	865	605.4	80.16	21.40	85.52	5	278.21	79.44	127.61	4.00	1.76	3.72
40	8.15	851	595.7	72.14	29.18	96.33	5	324.58	74.09	127.61	3.60	2.40	4.19
41	8.15	820	574.0	76.95	26.26	80.01	5	324.58	71.62	103.69	3.84	2.16	3.48
42	7.90	766	636.2	65.73	29.18	90.58	5	44.58	69.56	111.66	3.28	2.40	3.94
43	7.2	812	568.4	70.54	27.23	83.91	5	324.58	58.86	111.66	3.52	2.24	3.65
44	7.8	770	539.0	64.12	25.29	97.48	4	347.77	67.09	95.71	3.20	2.08	4.24
45	7.6	735	514.5	56.12	26.26	105.98	4	324.58	69.15	111.66	2.80	2.16	4.61
46	8.1	889	622.3	72.14	28.21	81.61	5	312.99	48.16	127.61	3.60	2.32	3.55
48	7.75	796	557.2	65.73	27.24	97.71	5	301.40	76.15	127.61	3.28	2.24	4.25
49	7.9	1162	813.4	102.60	26.96	97.71	5	301.40	94.67	207.37	5.12	3.04	4.25
50	7.95	950	665.0	91.38	28.21	73.80	6	324.58	59.68	95.71	4.60	2.32	3.21

– not measured

available records of annual precipitation and evaporation of a station located nearby the area are presented in bar graphs, (Figs. 2 and 3). These figures show that, the amount of rainfall reached its highest value in 1985, whereas in the same year the evaporation losses were less compared with the previous years.

In epm						Ions Percentage						TH	SAR
	K^{+1}	HCO_3^{-2}	SO_4^{-2}	Cl^{-1}	Ca^{+2}	Mg^{-2}	Na^{+1}	K^{+1}	HCO_3^{-1}	SO_4^{-2}	Cl^{-1}	ppm	epm
	.13	7.08	2.21	5.40	41.3	25.1	32.7	.9	48	15.39	36.61	476.1	2.15
	.13	5.70	2.32	6.30	44.79	21.97	32.32	.92	7.80	16.20	43.99	472.2	2.10
	.15	9.50	2.42	6.75	38.07	21.63	39.48	.81	10.88	12.96	36.15	352.1	3.11
	.13	7.60	1.71	4.05	39.94	22.99	36.68	.98	56.89	12.80	30.31	416.1	2.34
	.13	5.70	1.98	4.50	38.03	24.69	36.20	1.08	46.8	16.26	36.95	376.0	2.24
	.13	7.60	2.45	5.625	36.84	24.38	37.94	.84	43.5	15.63	35.90	472.0	2.70
	.10	5.70	1.08	3.375	30.52	23.29	45.18	1.00	56.16	10.64	33.25	268.0	2.74
	.08	7.22	4.76	11.925	35.99	35.65	28.01	.34	30.21	19.91	49.90	843.6	2.27
	.10	5.70	4.14	31.50	43.20	33.09	23.47	.25	13.80	10.02	76.27	1546.6	2.42
	.05	7.08	1.15	2.70	37.91	18.96	42.65	.47	84.78	10.52	24.70	300.1	2.60
	.18	5.70	1.83	4.95	56.91	25.87	15.76	1.46	45.67	14.66	39.66	512.2	0.86
	.10	6.08	1.25	2.70	39.20	28.8	31.00	1.00	60.62	12.46	26.92	340.0	1.68
	.13	6.08	1.47	3.60	33.45	26.91	38.45	1.18	64.53	13.18	32.29	332.0	2.32
	.13	7.08	2.03	4.05	43.39	18.98	36.52	1.10	53.80	15.43	30.77	372.2	2.25
	.15	6.46	1.36	4.05	39.42	25.83	33.47	1.27	64.42	11.46	34.12	384.0	2.01
	.13	6.46	1.24	3.6	34.69	21.68	42.46	1.17	67.17	10.97	31.86	312.0	2.66
	.13	7.08	1.14	3.15	37.23	18.25	43.34	1.18	62.23	10.03	27.70	304.1	2.72
	.13	5.70	1.42	4.05	37.82	23.27	37.73	1.18	61.03	12.71	36.26	336.0	2.26
	.18	6.46	3.45	7.65	45.71	32.91	20.34	1.03	36.79	19.65	43.56	441.9	1.36
	.18	5.89	3.60	8.00	48.44	26.76	23.76	1.04	38.49	20.64	45.81	652.1	1.61
	.13	5.32	1.51	4.05	43.20	20.86	34.73	1.21	43.90	13.888	37.22	344.1	2.01
	.13	5.70	1.59	3.60	38.59	25.97	34.23	1.21	52.34	14.60	33.06	348.0	1.98
	.13	5.32	1.88	4.05	43.40	17.36	38.06	1.18	47.29	16.71	36.00	336.2	2.30
	.15	5.70	1.83	3.60	35.00	26.35	37.37	1.37	51.21	16.44	32.35	336.0	2.24
	.13	5.32	1.81	3.60	39.21	25.64	33.93	1.22	49.58	16.87	33.55	344.0	1.94
	.13	4.56	1.65	3.60	41.62	18.31	38.71	1.35	48.48	16.82	36.70	288.1	2.19
	.13	5.32	1.54	3.60	34.88	23.25	40.60	1.26	50.86	14.72	34.42	300.0	2.42
	.13	5.32	1.49	2.925	39.96	22.47	36.21	1.35	54.68	15.31	30.06	300.0	2.01
	.13	5.32	1.45	3.15	33.64	24.62	40.41	1.33	53.63	14.62	31.57	283.9	2.34
	.13	5.32	1.23	3.15	36.70	23.48	38.26	1.36	54.85	12.68	32.47	288.0	2.15
	.10	5.70	1.40	2.70	33.26	21.62	44.07	1.04	58.16	14.29	27.55	264.0	2.61
	.10	5.32	1.44	3.15	28.96	22.34	47.67	1.03	53.68	14.53	31.79	248.0	2.93
	.13	5.13	1.00	3.60	37.50	24.17	36.98	1.35	52.72	10.28	37.00	296.0	2.06
	.13	4.94	1.59	3.60	33.13	22.60	42.93	1.31	48.76	15.70	35.54	276.0	2.56
	.13	4.94	1.97	3.85	40.83	24.24	33.89	1.04	38.71	13.09	56.85	367.0	2.10
	.15	5.32	1.24	2.70	44.75	22.57	31.23	1.46	57.45	13.39	29.16	344.1	1.73

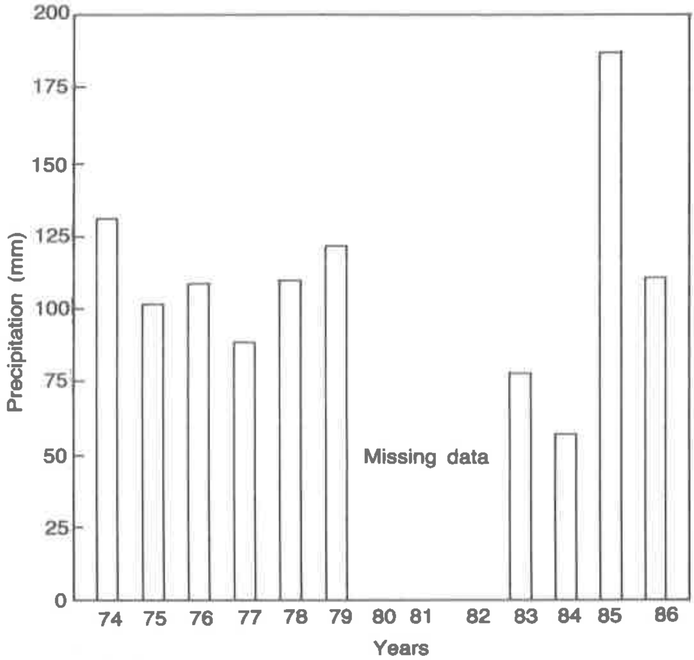

Fig. 2. Annual precipitation

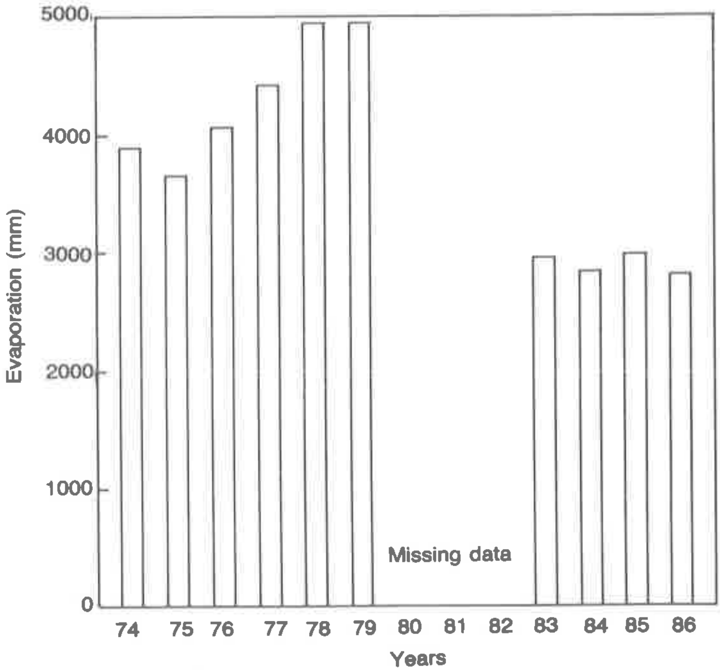

Fig. 3. Annual pan evaporation

Data Discussion

The hydrochemical analysis of the water samples in years 1981 and 1987, are summarized in the following form:

Ion	Concentration Range in epm	
	(1981)	(1987)
Ca	28 – 66	28 – 56
Mg	4 – 30	17 – 35
Na	16 – 60	16 – 47
K	0.12 – 3.4	0.25 – 1.46
HCO_3	8.2 – 53	14 – 67
SO_4	8 – 40	10 – 20.6
CI	30 – 74	25 – 76
pH	6.2 – 7.4	7.6 – 8.35
E.CMS/cm	700 – 10000	770 – 5010
T.D.S (ppm)	453 – 7000	514 – 3507
TH	98.5 – 3000	248 – 1547
SAR	0.6 – 8.71	0.86 – 3.11

The above table demonstrates, in general, that the concentration decreased in 1987. However, the graphical relation between the ranges of each ion (cations and anions) individually and the frequency of water samples, for the years 1981 and 1987 (Figs. 4 and 5) indicate that, there is an increase in the frequency of the lowest range concentrations of the year 1987.

The evaluation of the ground water quality in Al-Yamaniyah area for domestic and agricultural supplies, is deduced on the basis of the methods proposed by Sawyer and Mc Carty (1967), Davis and De Wiest (1966) and Richards (1974). The first one used the total hardness (TH) to evaluate the water for household cleaning purposes, while the second method applied the total dissolved solids (TDS) for ordinary water supply uses and the third one considered the sodium absorption ratio (SAR) for agricultural supply. The class ranges of each method are plotted against the frequency in bar forms (Figs. 6 and 7) respectively. The constructed figures exhibit the development of the water quality from the year 1981 to the year 1987. They show that most of the water are of a fresh-type for ordinary use, and some are excellent for agriculture. In general over the period investigated the water become softer.

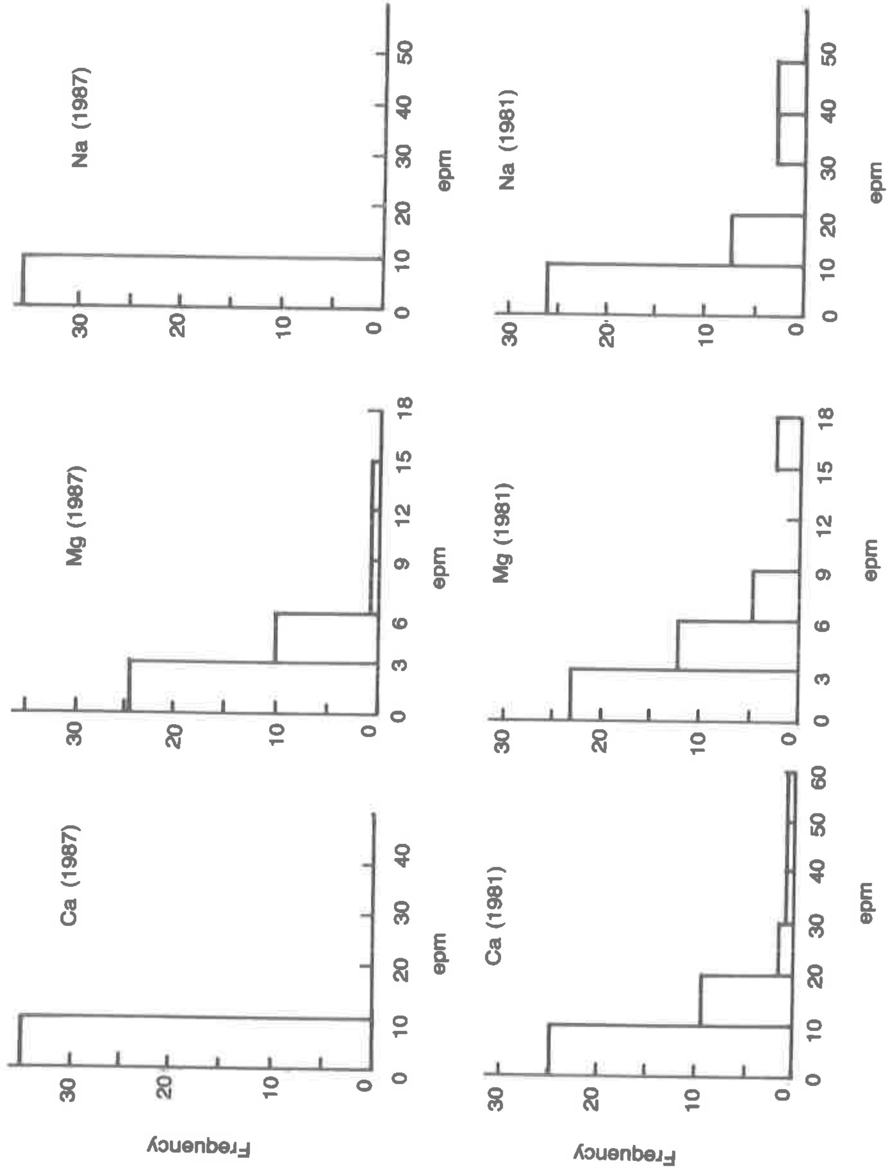

Fig. 4. Cation concentration frequency

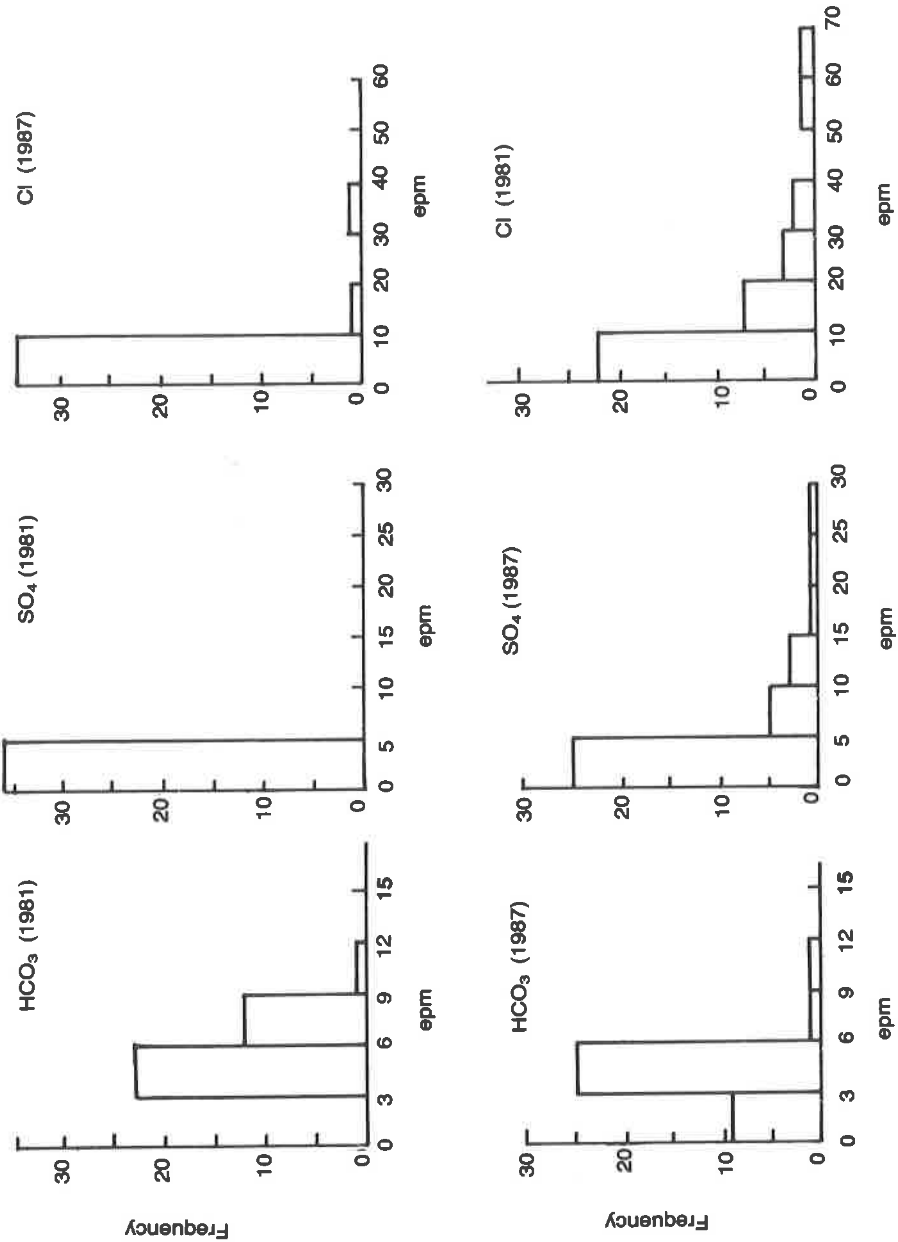

Fig. 5. Anionn concentration frequency

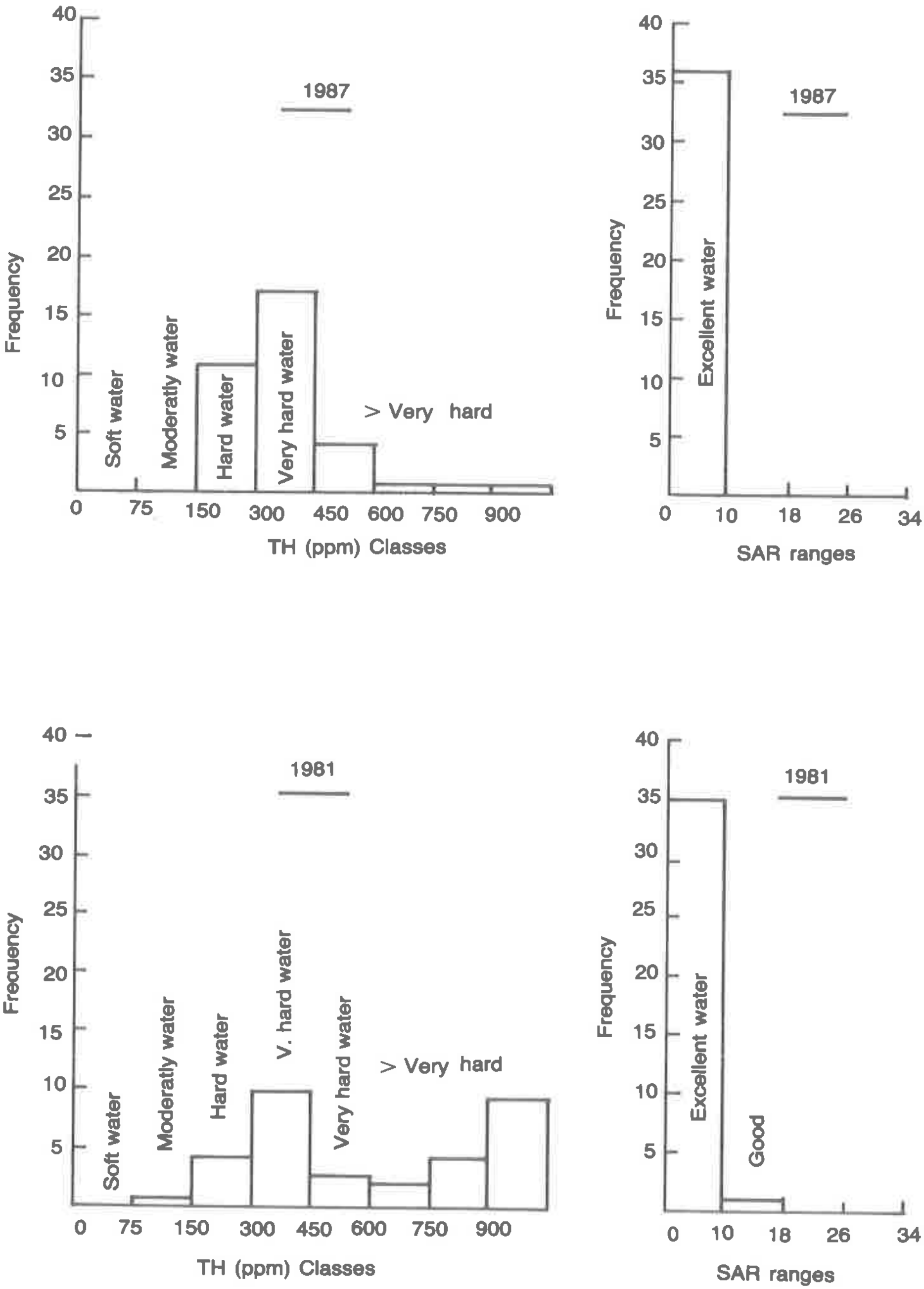

Fig. 6. Ground water evaluation methods frequency

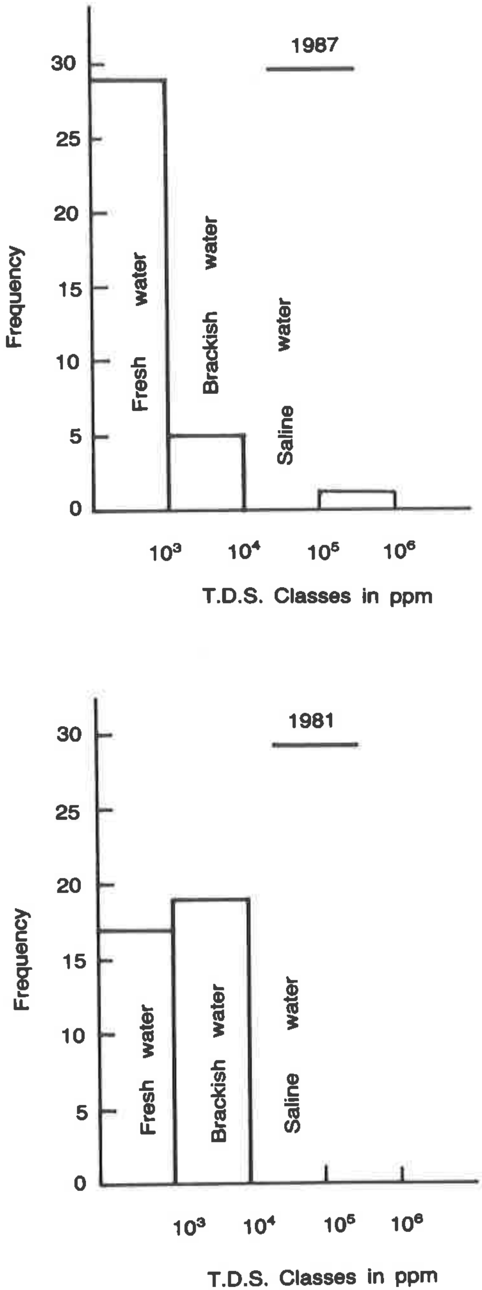

Fig. 7. Total dissolved solids frequency

For a general water classification, the data are plotted in trilinear diagrams (Figs. 8 and 9). These figures show that the anions concentration of Cl and SO_4 are high in the two sets of analyses whereas the concentration of HCO_3 increased in year 1987, *i.e.* the water became more alkaline. This is also confirmed by Figure No. 10, which shows that the frequency in the pH class from 8 to 8.5 is more than other classes. On the other hand, the Mg is slightly increase which is taken as an indication of precipitation recharge (Matthes 1982). But commonly, both sets of water analyses lie in one class of the trilinear classification.

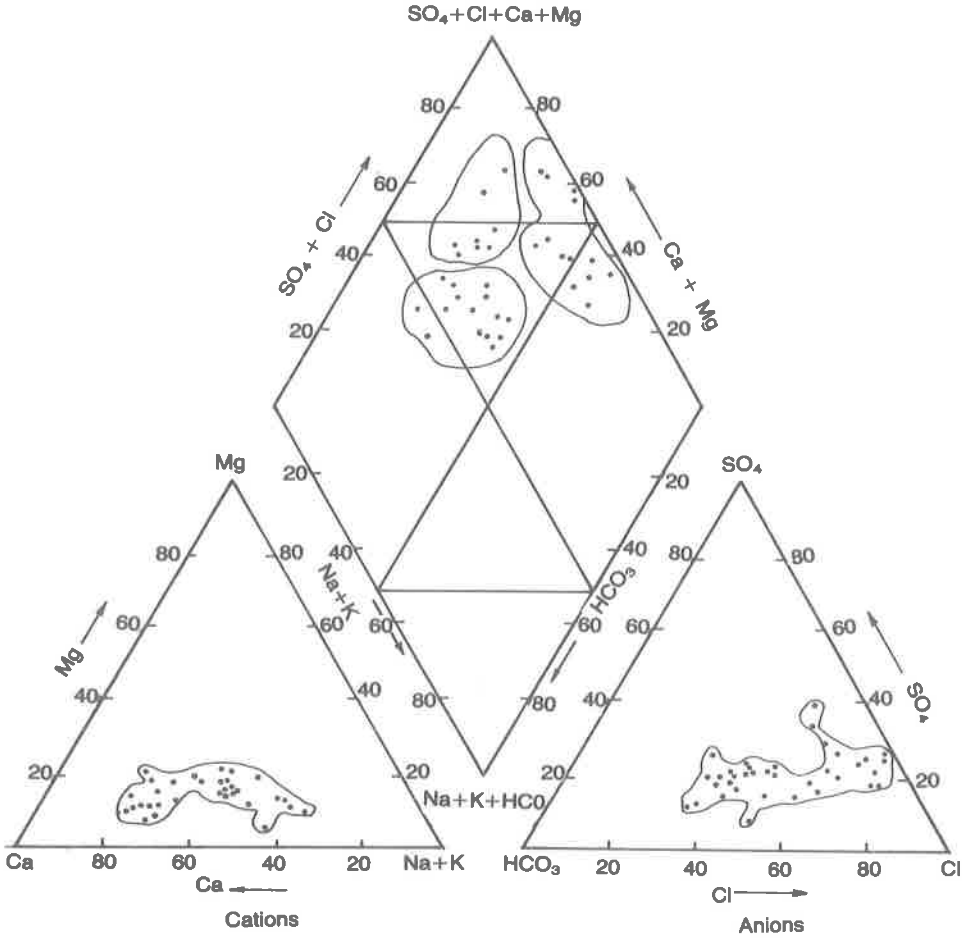

Fig. 8. Trilinear diagram for the water analysis of the year 1981

Conclusions

The evaluation of wadi Al-Yamaniyah ground water chemistry has been studied by comparing data sets from 1981 and 1987. The interpretation has been in the form of tables, histograms and trilinear relationship related to other available records such as precipitation. The abstruction from the aquifer in year 1987 increased to an extent that the ground water level has been lowered seven meters compared to measurements made six years before but the recent water analyses show that the ground water of Al-Yamaniyah has been lower in salinity in 1987

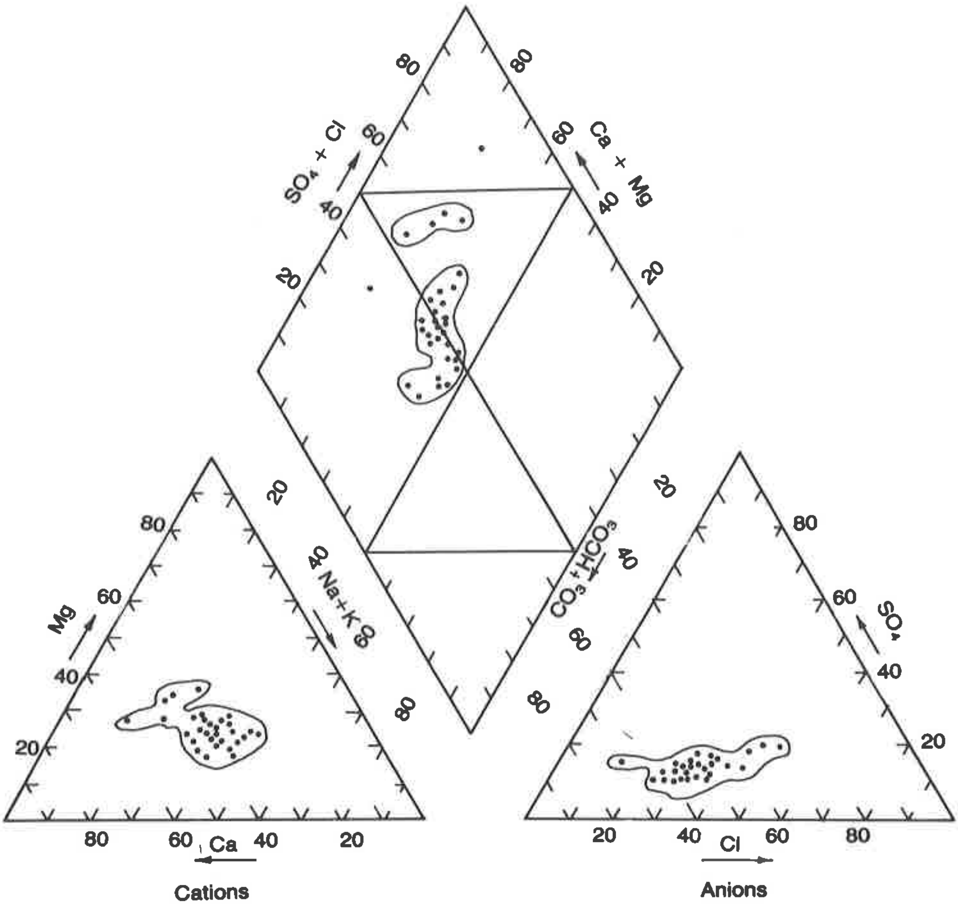

Fig. 9. Trilinear diagram for the water analysis of the year 1987

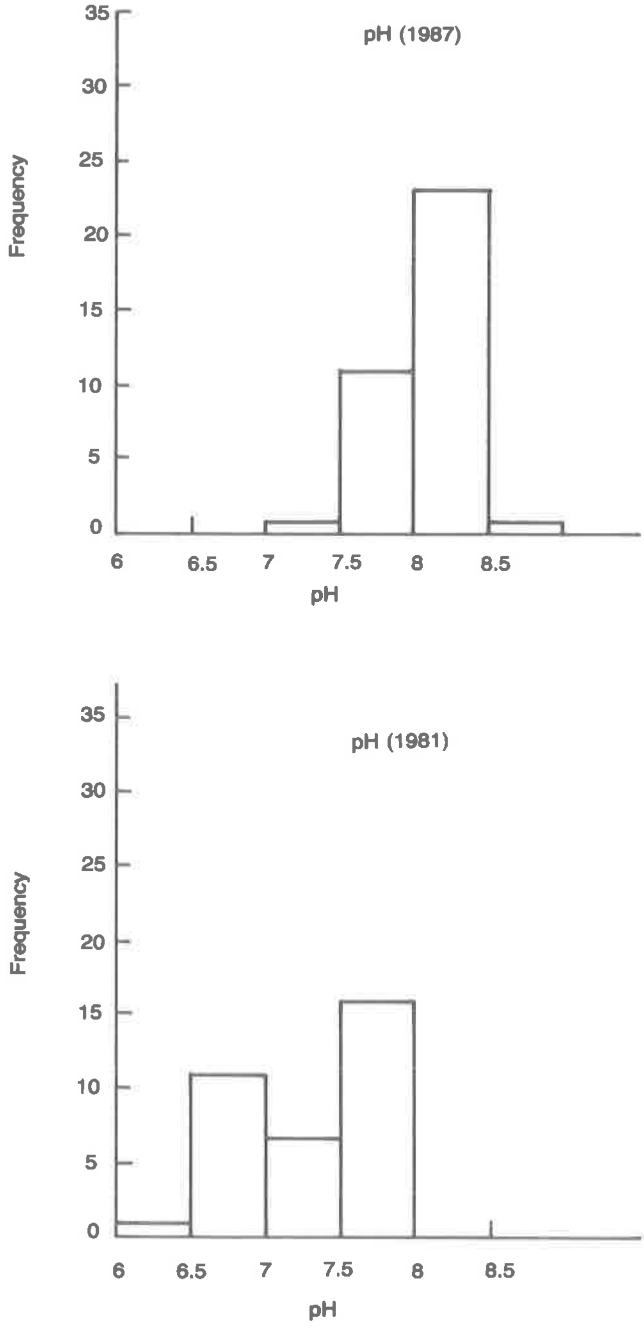

Fig. 10. pH values frequency

and gave a better water for domestic and agriculture uses. This could be due to the removal of some salts precipitated before the year 1972, as later that year the discharge of water from the hand-dug wells began, *i.e.* the movement of water in the aquifer of Al-Yamaniyah cleaned out the evaporite salts.

In the future, the ground water of Al-Yamaniyah is expected to have good quality and will be an excellent water as an aid to the important cities of Makkah and Taif.

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تقويم نوعية المياه الجوفية في وادي اليمانية بالمملكة العربية السعودية

عبدالغفار بازهير و ابو بكر الكاف

قسم جيولوجيا المياه ـ كلية علوم الأرض ـ جامعة الملك عبدالعزيز ـ جدة ـ المملكة العربية السعودية

يقع وادي اليمانية بالمملكة العربية السعودية بالقرب من مدينتين مهمتين وهما مكة المكرمة والطائف، مصيف حكومة المملكة العربية السعودية وتبعاً لذلك فإن دراسة المياه الجوفية بالوادي تعتبر مهمة وبالرغم مما سبق إلا أن الدراسات الهيدروجيولوجيه للوادي قليلة ويرجع ذلك إلى أن استخدام مياه متكون الوادي بدأ بعد عام ١٩٧٢م.

في سنه ١٩٨١ م قام الباحث الدكتور عبدالغفار سعيد بازهير بدراسة وادي اليمانية دراسة هيدرولوجية عامة وأوصى باستمرار دراسة التغير كمياً وكيفياً وذلك لازدياد سحب المياه من الوادي.

أن هذا البحث يركز بصفة خاصة على دراسة نوعية المياه بالوادي وقد تم تجميع عدد من العينات يماثل العدد التي تم تجميعها عام ١٩٨١، وكذلك الموقع، وتم تحليل العناصر الاساسية الموجودة بالماء، وباستخدام طرق إحصائيه لمعدلات الاقسام الخاصة بتقييم الماء للاستخدام المحلي والزراعي بتطبيق عدة طرق بالاستعانة بمعلومات عن الامطار والتبخر وكذلك قياس كميات المياه التي تضخ من الوادي والتي إزدادت بمقدار أكثر من الضعف عما كان عليه عام ١٩٧٩، والتي أدت إلى إنخفاض مستوى الماء إلا أنه بالرغم من ذلك فإن النتائج بينت ان نوعية المياه تحسنت إلى الأفضل سواء للاستخدام المحلي أو الزراعي واستنتج من ذلك أن المتكون تخلص من مجموعه من الأملاح المترسبة والمركزة قبل عام ١٩٧٢ م وهذا يعطى دليلاً على أن المياه الجوفية ستتحسن لتكون مصدراً ذا نوعية جيدة لمكة المكرمة والطائف وللمنطقة.