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Geological and geochemical studies on the underground water characteristics in the area between Marsa Alam and Baranees-Red Sea- Egypt

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Abstract

Thirty nine Groundwater samples were collected from the available water points from the study area, is located at the southern part of the Red Sea, it lies between Marsa Alam at the north and Baranees at the south. From the results it is visible that the highest concentration of major and trace elements in the underground water samples collected from different wells might be due to either one or more of the following: 1) presence of limestone and gypsum rocks, 2) it might be related to the sea water intrusion as it locates near the sea, 3) as a result of leaching of the wadi sediments by the floods, 4) or water flow as in the Abu Ghusun wells. On the other hand, the lowest concentration of trace and major elements except for the cobalt in most of the wells is related to the basement rocks of the aquifer in these wells, and all of these wells are far from the coastal plain so the water type related to the aquifer type and the wadi sediments. In the present work, the available groundwater resources are subjected to evaluation for only livestock and agricultural purposes.

1. Introduction

The Red Sea area is dominated by an arid climate, and nearly all of the erosion processes are directly related to these desert conditions. Wind erosion plays a dominant role in the development of the present landscape. No permanent rivers flow into the Red Sea at present. Much of the spectacular relief in the area is related to tectonic movements as a result of the opening of the Red Sea (Robert, 1993).

Nearly all the exposed rocks surrounding the Red Sea Basin are Precambrian in age and have undergone repeated deformation, intrusion, and metamorphism. These rocks appear to have been derived from oceanic suites of basaltic and andesitic rocks associated with flysch and deep ocean basin deposits. The mobilized basement and intrusive rocks yield ages of 500 to 900 Ma, representing late phanerozoic cratonization (Clifford 1970; Stacey and Hedge, 1984).

The study area is located at the southern part of the Red Sea, it lies between Marsa Alam at the north and Baranees at the south, between longitudes 34º 54́ and 35º 34́ and latitude 25º 4́ and 24º 6́. Its eastern side is extended along the Red Sea Coast with a distance of about 130 Km and extends to the west through the Eastern Desert until the watershed of the Red Sea basement rocks with a distance of about 60 Km. It covers a surface area of about 7485 Km² (Figure 1).

The area is accessible through three asphaltic roads, the first one is along the Red Sea Coast of about 130 km from Marsa Alam to Baranees. The second road extends to 220 km from Idfo on the Nile to Marsa Alam on the Red Sea Coast. The third one extends to about 200 km from Aswan on the Nile valley to Baranees on the Red Sea Coast.

The objective of the study is to define the hydrological setting of the groundwater in the study area. Hydrological and hydrogeochemical studies were carried out to realize the aforementioned objectives.

The water wells distribution is shown on the location map of Figure 2. Their locations are indicated in Table 1.

Hydrogeology of the study area

Water-bearing formations in the area of study

In the investigated area, the groundwater is tapped from the following water-bearing formations:

- Quaternary water bearing formation.
- Pliocene water bearing formations.
- Miocene water bearing formation.
- The fractured Precambrian water bearing formation.

The hydrogeologic setting is arised from the geological features in the area around the wells, lithologic succession and the water bearing formations reached by the predrilled wells, besides the previous work. Table 1 summarizes wells names, symbology, coordinates, water table depth, water table elevation, water bearing formation, drilling method, drilling authority, and the aquifer type.

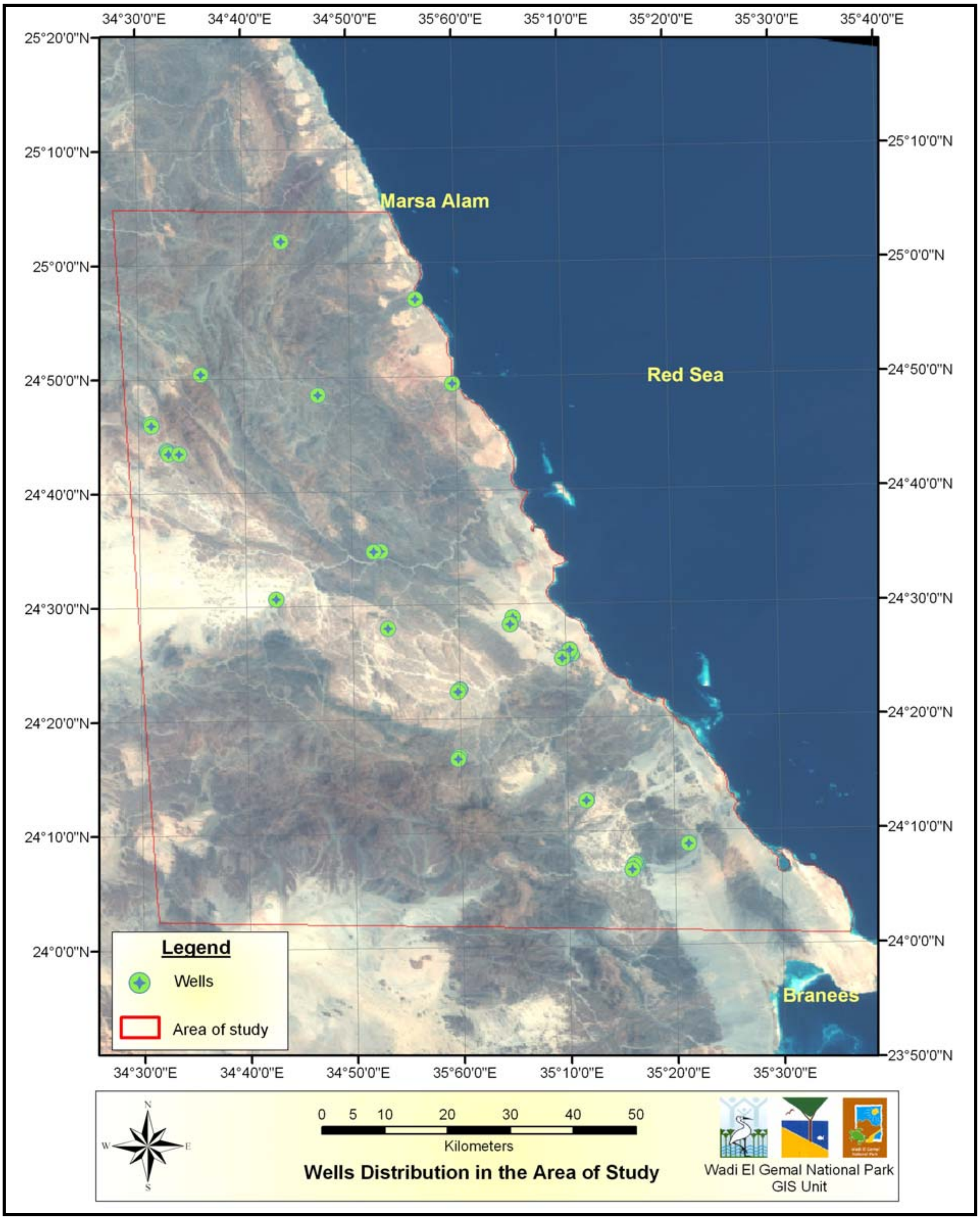


Figure 1: Location map of the studied area with sampling wells.

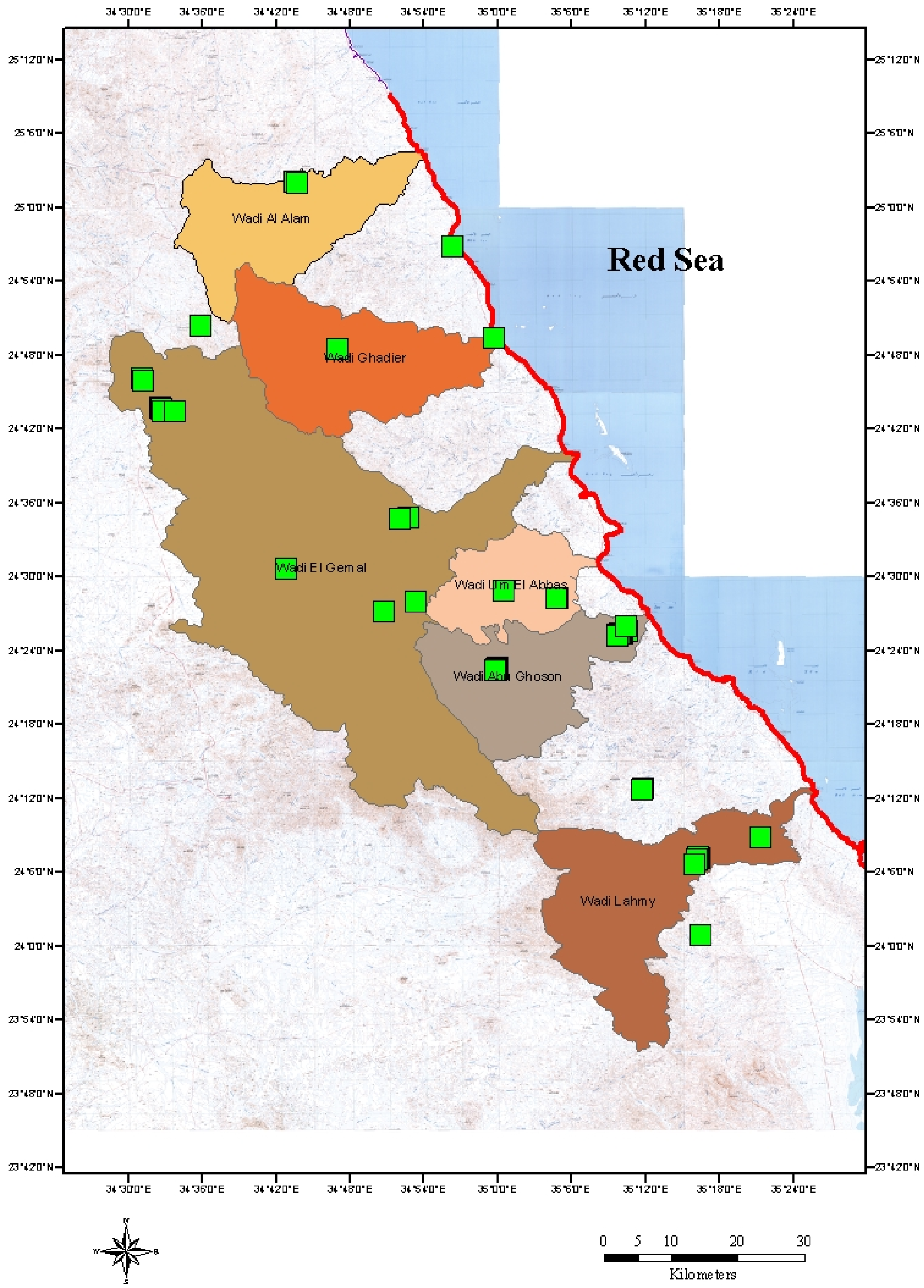


Figure 2: Location map of the water wells of the study area.

Table1: Summarize wells names, symbology, coordinates, water table depth, water table elevation, water bearing formation, drilling method, drilling authority, and the aquifer type.

S.N.	Symbol	Name	Latitude			Longitude			W.T.	W.T.E	W.B.F	D.method	D. authority	Aquifer type
1	AG1	Wadi Abu Ghusun wells	24	25	32.4	35	10	33	11	29	Quaternary	H. dug	L. people	unconfined
2	AG2	Wadi Abu Ghusun wells	24	25	22.7	35	10	8.1	8.8	43	Quaternary	H. dug	WFP	unconfined
3	AG3	Wadi Abu Ghusun wells	24	25	21.5	35	10	1.5	8.8	42	Quaternary	H. dug	WFP	unconfined
4	AG4	Wadi Abu Ghusun wells	24	25	18.8	35	9	53	11	41	Quaternary	H. dug	WFP	unconfined
5	AG5	Wadi Abu Ghusun wells	24	25	14.5	35	9	46	14	41	Quaternary	H. dug	WFP	unconfined
6	AG6	Wadi Abu Ghusun wells	24	25	9.7	35	9	41	14	40	Quaternary	H. dug	WFP	unconfined
7	GD1	Wadi El Ghadir wells	24	49	20.7	34	59	41	4.3	9	Quaternary	H. dug	L. people	A. Deposits
8	GD2	Wadi El Ghadir wells	24	48	28.5	34	46	59	4.2	297	Quaternary	H. dug	L. people	unconfined
9	AM	Wadi El Ambaout well	24	56	48	34	56	18	1.8	6	Quaternary	H. dug	L. people	A. Deposits
10	EL1	Wadi Um El Abbas wells	24	28	47.9	35	0.5	0.4	17	65	Quaternary	Rotary	WFP	confined
11	EL2	Wadi Um El Abbas wells	24	28	11.3	35	4	49	18	72	Quaternary	Rotary	TDA	confined
12	EL3	Wadi Um El Abbas wells	24	28	11.4	35	4	48	18	73	Quaternary	Rotary	TDA	confined
13	LH1	Wadi Lahmi wells	24	8	47.1	35	21	19	48	48	Pliocene	Rotary	TDA	confined
14	AGS1	Wadi Abu Ghusun salty wells	24	25	55.1	35	10	23	1.4	111	Miocene	H. dug	L. people	unconfined
15	AGS2	Wadi Abu Ghusun salty wells	24	25	53.8	35	10	23	1.7	108	Miocene	H. dug	L. people	unconfined
16	LH2	Wadi Lahmi wells	24	0.7	5.5	35	16	29	21	175	Precambrian	H. dug	L. people	F. P.R
17	LH3	Wadi Lahmi wells	24	7	2.4	35	16	24	21	179	Precambrian	H. dug	WFP	F. P.R
18	LH4	Wadi Lahmi wells	24	7	8.9	35	16	18	22	186	Precambrian	H. dug	WFP	F. P.R
19	LH5	Wadi Lahmi wells	24	6	59.1	35	16	10	18	193	Precambrian	H. dug	WFP	F. P.R
20	LH6	Wadi Lahmi wells	24	6	35	35	15	58	18	194	Precambrian	H. dug	WFP	F. P.R
21	HE1	Wadi El Ridi wells	24	12	42.4	35	11	47	11	260	Precambrian	H. dug	L. people	F. P.R
22	HE2	Wadi El Ridi wells	24	12	40.3	35	11	46	6.9	266	Precambrian	H. dug	L. people	F. P.R
23	RO1	Wadi Romit wells	24	22	33.8	35	0	3.1	21	278	Precambrian	H. dug	WFP	F. P.R

Table1 continue

24	RO2	Wadi Romit wells	24	22	30	34	59	57	20	279	Precambrian	H. dug	L. people	F. P.R
25	RO3	Wadi Romit wells	24	22	21.1	34	59	48	22	293	Precambrian	H. dug	WFP	F. P.R
26	AB	Wadi El Abyad	24	27	9.1	34	50	47	13	383	Precambrian	H. dug	L. people	F. P.R
27	WG1	Wadi El Gimal wells	24	30	37.9	34	42	48	13	330	Precambrian	H. dug	L. people	F. P.R
28	WG2	Wadi El Gimal wells	24	34	44.1	34	52	43	2	376	Precambrian	H. dug	L. people	F. P.R
29	WG3	Wadi El Gimal wells	24	34	42.5	34	52	5.1	0	288	Precambrian	H. dug	L. people	F. P.R
30	TR1	Wadi Um Khirayjah wells	25	2	2.5	34	43	32	16	275	Precambrian	H. dug	unknown	F. P.R
31	TR2	Wadi Um Khirayjah wells	25	1	58.8	34	43	44	16	256	Precambrian	H. dug	WFP	F. P.R
32	HA	Wadi Hangalia	24	50	23.6	34	35	55	26	745	Precambrian	H. dug	unknown	F. P.R
33	HG1	Wadi Um Hegleg	24	43	44.2	34	32	37	19	525	Precambrian	H. dug	L. people	F. P.R
34	HG2	Wadi Um Hegleg	24	43	37.6	34	32	43	24	512	Precambrian	H. dug	WFP	F. P.R
35	HG3	Wadi Um Hegleg	24	43	26.3	34	32	48	23	503	Precambrian	H. dug	WFP	F. P.R
36	HF1	Wadi Hafafit	24	46	6.7	34	31	9.4	23	545	Precambrian	H. dug	L. people	unconfined
37	HF2	Wadi Hafafit	24	45	55.6	34	31	13	19	551	Precambrian	H. dug	WFP	unconfined
38	UM GH	Wadi Um Ghanam	24	43	26.9	34	33	48	17	524	Precambrian	H. dug	L. people	unconfined
39	SO	Wadi Um Soeh well	24	27	56.8	34	53	18	2.7	407	Precambrian	H. dug	L. people	unconfined

Abbreviation:

H. dug: Hand dug wells
TDA: Tourism development authority
W.T. Water table
W.T.E Water table elevation
L. people: Local people
WFP: World food program project
W.B.F: Water bearing formation
D. Method: Drilling mthod
D. Authority: Drilling authority
A. Deposits: Alluvial Deposits
F. P. R: Fractured precambrian rocks

I- Quaternary water bearing formation

The Quaternary deposits composed mainly of detritals of sand, silt and gravels of different rock types; this constitutes the main aquifer which is tapped in different localities by shallow hand dug wells at the fans of some Red Sea drainage basins, and also constitutes the deep drilled wells in the areas that classified from geomorphic view as a depression.

El Ambaut well

El Ambaut well (AM) is a hand dug well. It locates at the down stream part of wadi El Ambaut, far from the Red Sea shoreline by a distance about ½ km (Figure 1). The area around the well is a Quaternary terraces and alluvial deposits. The depth to water table recorded 1.80m, and the water table elevation was 6 m (Table 1).

Wadi El Ghadir wells

Two hand dugs wells registered in wadi El Ghadir (Figure 2). The first one is a coastal well (GD1), it locates at the north eastern part of wadi El Ghadir alluvial fan, and far from the Red Sea shoreline by a distance less than ½ km. The depth to water table was 4.30m, and the water table elevation was 9 m (Table 1). The second well locates far from wadi El Ghadir entrance by a distance about 35 km (GD2). This well drilled through the wadi fill deposits, and surrounded by andesite rocks. The water table depth of this well was 4.20 m and the water table elevation was 297 m.

Abu Ghusun wells

A large number of wells reach to six wells (AG1, AG2, AG3, AG4, AG5, and AG6) drilled in the downstream part of wadi Abu Ghusun. These wells locate far from the coastal area by about 4 km to 6 km (Figure 1).

All of Abu Ghusun wells are drilled by hand dug method. One of these wells (AG1) was drilled by the local people several years ago, and the other five wells were drilled by the WFP Project through the year of 2005 - 2007. The lithologic succession described according to well (AG4) as follow and as shown in (Figures 3a&b).

Um El-Abas Well s

Two wells (EL1, EL2) reach to 108 m depth, and the third (EL3) reachs to about 40 m. The probability of presence water according to the lithologic succession is at depths range from 23 m to 33 m, 42 m to 47 m, and 65 m to 85 m (EMRA, 2005). The three wells drilled in Um El Abas considered as a confined reservoir. The large thickness of sediments in this area in relation to other areas give an indication that this area is a depression and may have a large amount of water. Figure 4 shows the lithologic succession of Um-El-Abas Wells (EL1 and EL2) according to the EMRA.

- Pliocene water bearing formation

Wadi Lahmi well (LH1)

The Pliocene water bearing formation in the study area is confined Gabir Formation. According to geologic map (1997) this formation is described as yellow to brown calcareous sandstone, green marl, oolitic limestone, and conglomerate. The water bearing formation is a sand bed extends from 41 m to 54 m depth with 13 m thickness. This bed deposited under confined conditions as it restricted between two marl beds as an impermeable strata. The lithologic section ended with a coral reef based on the basement rock at 100 m depth as indicated in the figures 5a&b.

- Miocene water bearing formation:

Abu Ghusun salty wells:

Miocene water bearing formation is included in Abu Dabbab Formation. This formation was described as a thick, massive anhydrite and gypsum beds intercalated with marl, silty clay sandstone and dolomitic limestone. The Miocene water bearing formation was detected in the two wells (AGS1, AGS2). These wells located in small tributary branched from Wadi Abu Ghusun.

- Precambrian water bearing formation

Missing Sawsan *et al*. (2006) mentioned that, the great extension, high elevation, and dense fracture system of the Precambrian watershed-mountains give the importance of the rocks as groundwater channels. On the other hand, certain zones in the basement rocks are highly weathered, fractured and jointed, which permits the accumulations and storage of the groundwater.

Wadi Lahmi wells

Five productive wells (LH2, LH3, LH4, LH5, LH6) were drilled by hand dug method. These wells locate in the upstream part of Wadi Lahmi. The lithologic units are fill deposits that end with boulders of basement rocks, and then the basement rocks (granite) appear at about 21 m depth in LH3 well. The lithologic succession can be described in Figures. 5a&b.

Wadi El Reidi well

One productive well called Heraterite well is located in the upstream part of wadi El Reidi. It is considered as the main water source for the livestock around this area. The lithologic succession has a thickness of 2.75 m, and the lower part of the lithologic section is fractured old granite rocks as a water bearing formation.

Wadi Romite wells

Three hand dug wells located in wadi Romite (RO1, RO2, RO3), "Wadi Amera". The area of Wadi Romite is composed mainly of white granite, that located near to granite quarries in Wadi Shawab. Figs. 6a&b show the lithologic succession and section crossing these wells.

Wadi El Gimal well

The well (WG1), among the Wadi El gimal wells, is located in the upstream part of wadi El Gimal, in the way of the flood so it covered by wadi deposits through flood. It is a hand dug well that drilled by the local community. The rock units around the well composed mainly of granite rocks.

El Abyad well

El Abyad well (AB) is located in Wadi El Abyad, which is one of the main tributaries for wadi El Gimal basin. This well was drilled by the local community through 2006. The rock units around the well composed mainly of granite rocks,

Um Soeh well

Wadi Um Soeh is a small tributary from Wadi El Gimal Drainage Basin, the rock units of this wadi composed mainly of granite rocks. Um Soeh well (SO) was drilled by hand dug method in the upstream part of this wadi.

Wadi Um Kabo springs

The area around the wells composed mainly of medium to coarse grained, variably deformed metagabbro, diorite and amphibolites. Wadi Um Kabo has two springs (WG2 and WG3) in the upstream part and through metagabbro rocks.

Wadi Um Heglega wells

Wadi Heglega is considered as a main wadi in Hafafit area, that related to Wadi El Gimal Basin and drain in Wadi Hafafit. Three wells were drilled in Wadi Um Heglega (HG1, HG2, and HG3) by hand dug method, HG1 well was drilled by the local people, HG2 and HG3 drilled by WFP Project. The water table depth ranges from 18.5 to 23.54 m, and the water table elevation ranges from 512 to 525m (Table 1). Fig. 7. shows the lithologic section of Um Heglega wells.

Wadi Um Ghanam well

Wadi Um Ghanam is a small wadi in Hafafit area. Um Ghanam well (UM GH), composed mainly of medium to coarse grained, locally gneissose, variably deformed tonalite and granodiorite, xenolithic and pegmatitic, (Geologic map, 1997). The water bearing formation in Um Ghanam well is gneissose rocks, this detected through deepening of the well in 2003.

Hafafit wells

Hafafit wells (HF1, HF2) are located in the western side of the asphalt road that extend from Sheikh Salem to Sheikh Shazli, nearly far from Sheikh Salem by 45 km. Well (HF_1) is located beside a dyke composed mainly of feldspar, and cut through Wadi hafafit. The water table depth for this well is 23.4 m, and the water table elevation is 545m, while well (HF2) was drilled beside a dyke composed mainly of quartz and feldspar. The water table depth is 18.8m and the water table elevation is 551 m.

Three dry wells were drilled in hafafit area through basement rocks. The lithologic succession of these wells from top to bottom is alluvial deposits constitute the main section of the well, boulders with a thickness about one meter and then the basement rocks. Other wells drilled through Wadi Hafafit by the WFP Project without producing water. One of these wells reaches to 27m depth without producing water, this well has the same lithologic succession of the former wells.

Um Khirayjah wells

Two wells (TR1 and TR2) were drilled in the southern side of Marsa Alam Edfo road, far from Marsa Alam by about 20km. The rock units around the wells are composed mainly of metavolcanics, schist, and metasediments. The well TR_1 has the water table depth of about 15.7 m, and the water table elevation is 275 m from sea level. In the former time the water extract from this well by using a pump, but now the local people use the hand method. The second well TR2 has water table is 16.3 m depth, and the water table elevation from the sea level is 256m.

Wadi Hangalia well

Wadi Hangalia is located in the western part of the study area, to the north western side of Hafafit Mountain. Hangalia Well (HA) is the deepest hand dug well registered in the area of study, its water table depth was 26 m, and the water table elevation recorded 745 m. Figure 7 indicates the lithologic section of Um Hangalia Wells (HG_1, HG_2 & HG_3).

2. Material and Methods

Field work is basic module of this study, especially to describe the geologic setting of the area, to follow up drilling procedures in new wells, to confirm the data collected during the interviews, to identify the existing water resources, and to collect the water samples

Geologic map of scale 1:250000 was used in determining the geologic setting this in addition to field survey. GPS is used to register the coordinates of the wells sites. A digital elevation model (Oziexplorer program) is used to determine the elevations of different water points.

Groundwater samples were collected from the available water points representing the defined aquifers. The total number of samples is 39 samples. They were collected during September 2006. Among them; 12 samples represent the Quaternary aquifer, 1 sample represents the Pliocene aquifer, 2 samples represent the Miocene aquifer, and 24 samples represent the Precambrian aquifer.

Direct measurements were made at each well using the hydrolap equipment, giving readings for temperature, electrical conductivity (EC), dissolved oxygen (DO), redox potential (Eh), turbidity, total dissolved salts (TDS), and pH.

The atomic absorption method applied to study the hydrochemistry aspects of the thirty nine samples collected (institute of oceanography and fisheries in Hurghada). Samples were analyzed for major elements (Na, K, Ca, and Mg), and trace elements (Mn, Cu, Zn, Pb, Co, and Fe).

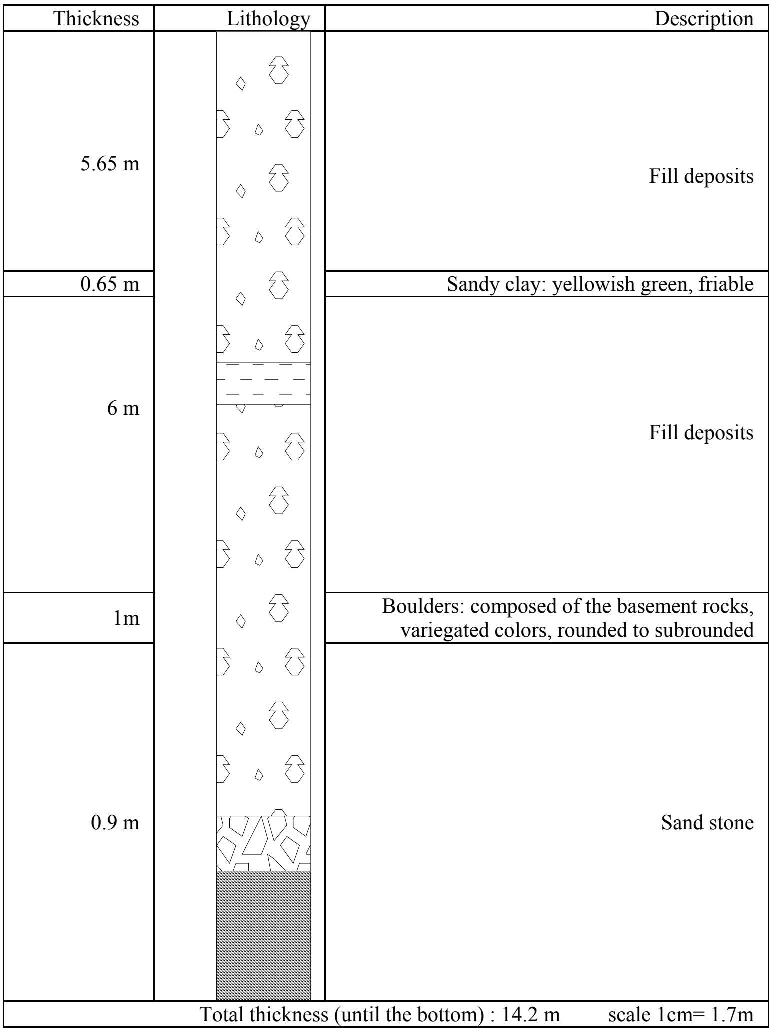


Figure 3a. Lithologic succession of Abu Ghusun wells (AG5, hand dug).

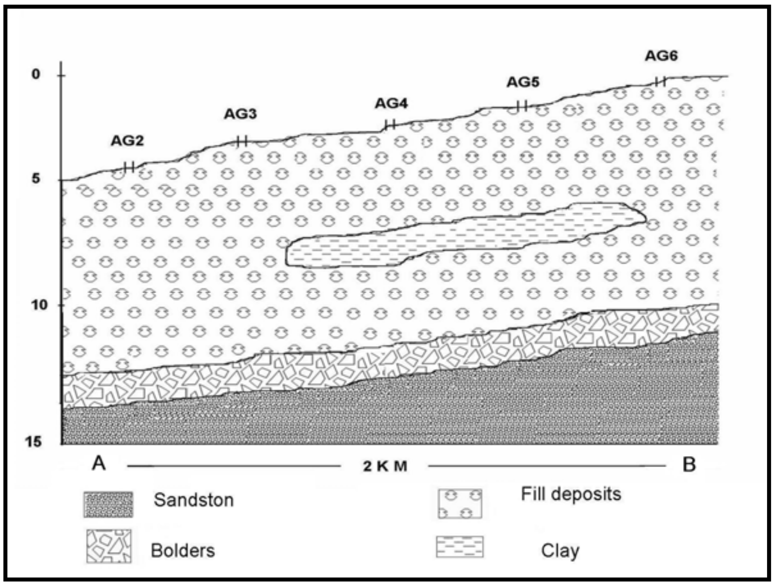


Figure 3b: Lithologic section for Wadi Abu Ghusun from AG2 well to AG6 well.

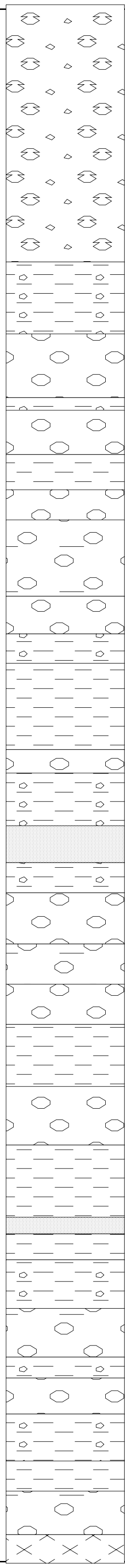
Depth		Thickness	Lithology	Description	
From	To				
0	17.8	17.8		Alluvial deposits	
17.8	22.7	4.9		Clayey sand	
22.7	27.3	4.6		Coarse sand	
27.3	29.3	1		Clayey sand	
29.3	32.5	3.2		Coarse sand	
32.5	35	2.5		Clay	
35	37.2	2.2		Coarse sand	
37.2	42.2	5		Clayey sand	
42.2	45	2.8		Coarse sand	
45	47	2		Sandy clay	
47	53	6		Clay	
53	54.5	1.5		Coarse sand	
54.5	56	3.5		Sandy clay	
56	60.4	2.4		Sand	
60.4	62.3	1.9		Sandy clay	
62.3	66	3.7		Coarse sand	
66	68.8	2.7		Clayey sand	
68.8	70.5	1.8		Coarse sand	
70.5	74.8	4.3		Clay	
74.8	78.7	3.9		Coarse sand	
78.7	83.7	5		Clay	
83.7	85	1.3		Sand	
85	87.3	2.3		Clay	
87.3	91	3.7		Sandy clay	
91	94.7	3.7		Clayey sand	
94.7	96.3	1.6		Sandy clay	
96.3	99	2.7		Coarse sand	
99	102.7	3.7		Sandy clay	
102.7	105	2.3		Clay	
105	108	3		Clayey sand	
				Basement rocks	
Total depth to the basement rocks: 108 m					

Figure 4: Lithologic description for Um El Abbas well.

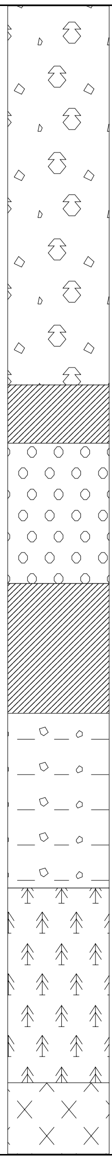
Depth		Thickness	Lithology	Description
From	To			
00	35	35		Wadi deposits: rock debrises from basement and sedimentary rocks
35	41	6		Marl: grey color
41	56	13		Sand: yellowish white, coarse to fine (water bearing bed)
56	68	12		Marl: grey color
68	84	16		Sand and shale alternations
84	100	16		Coral reef bed: dark grey color
100	106.35	6.35		Basement rocks
Total thickness: 106.35 m Scale 1cm=10m				

Figure 5a: Lithologic succession of Wadi Lahmi test well (report from EMRA to TDA).

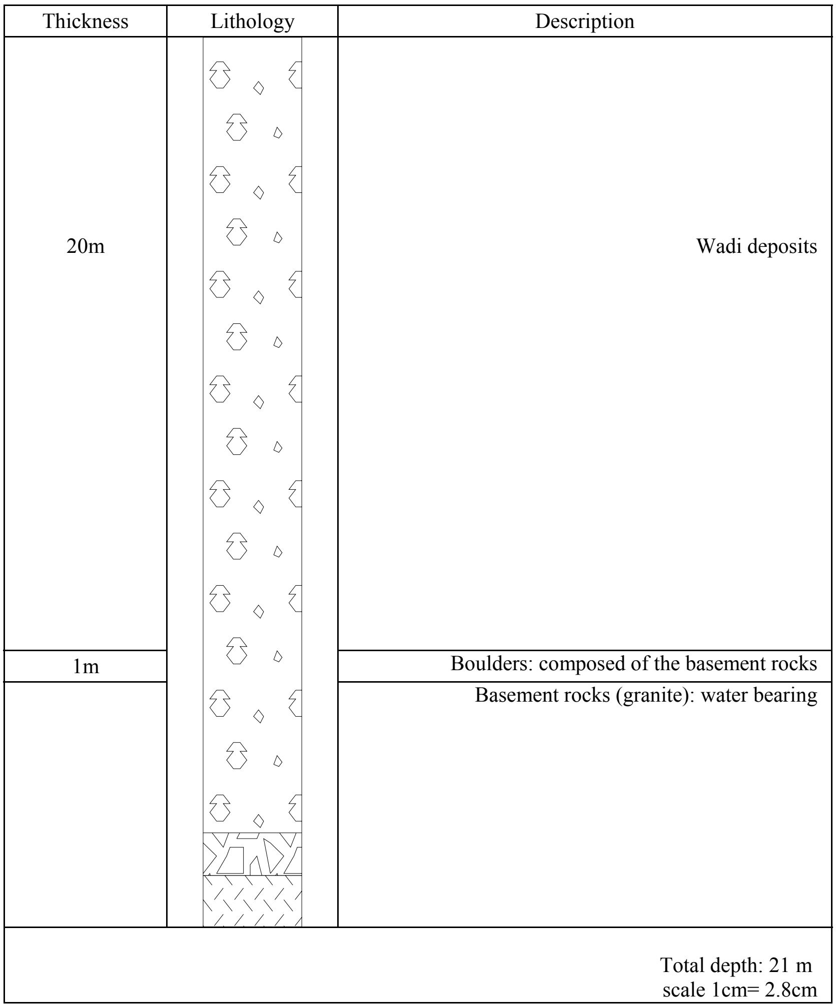


Figure 5b: Lithologic succession of Wadi Lahmi wells (LH3, hand dug well).

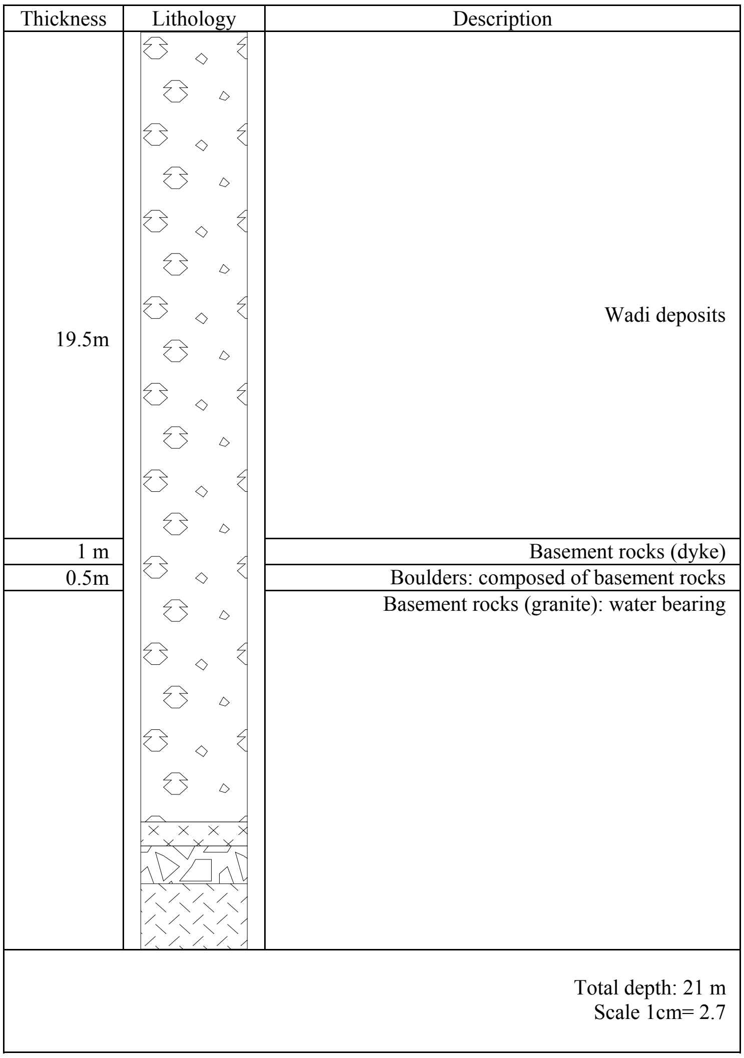


Figure 6a: Lithologic succession of Wadi Romite wells (RO5, hand dug).

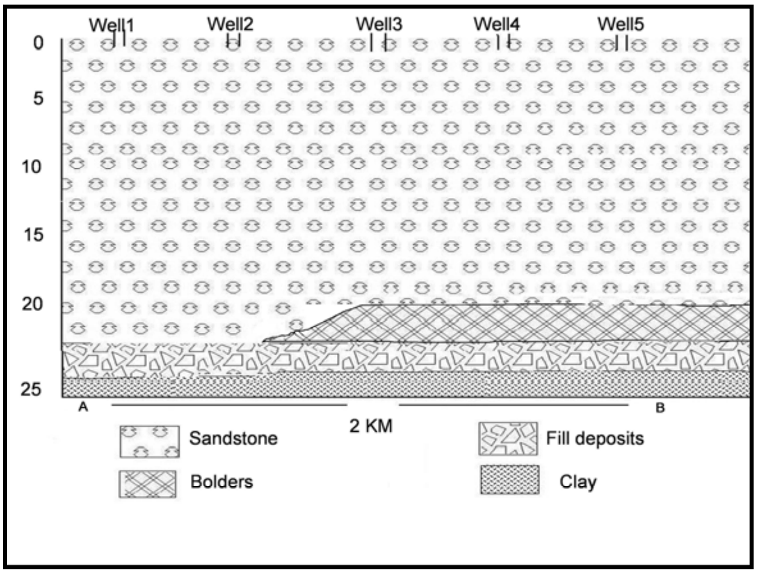


Figure 6b: Lithologic section from well 1 to well 5 in Wadi Romite.

3. Results

Basement rocks constitute the major rock units in the area. Sedimentary rocks are exposed along the coastal area with a width ranges from two to five kilometers. The Quaternary sediments, represent terraces along the coastal area or along the banks of different wadies, it also represented through the coastal sediments and the sand dunes.

Ground-water quality is dealing with many environmental factors. Climate, geology, biochemistry, composition of atmospheric precipitation, and the nature of the hydrology are among the more important factors. The source of most dissolved ions in natural waters is the mineral assemblages in the rocks near the land surface (Hem, 1985). Rock composition is only one of many related geologic factors; other geologic factors, such as nature of minerals, texture, porosity, and regional structure, can affect the composition of waters (Hem, 1985, Robinson, 1997). Rogers (1989) noted that the bedrock-aquifer waters are more chemically evolved probably because of longer contact time between the water and the aquifer matrix in the bedrock aquifer than in the stratified-drift aquifer.

Physical properties

The physical and chemical characteristics for the studied groundwater samples are determined in the field by using the hydrolap (Table 2). These characteristics can be summarizing as follow:-

Temperature

The daily mean temperature in September as recorded in Ras Banas station is 30.9ºC, the average temperature for the whole aquifer system is 28ºC, Romite well (RO3) registered the highest temperature. Wadi El Ghadir Well (GD2) registered the lowest temperature this might be due to the free contact with the atmosphere (shallow well).

pH value

The pH values are ranging between 6.6 and 9.6 with an average 7.4.The average of pH value for the Quaternary aquifer is 2.7, for the Pliocene aquifer is 7.3, the average value for the Miocene aquifer is 7.2, and for the Precambrian aquifers is 7.5. All wells express about alkaline characters except for EL1, EL3 wells that expressed about neutral characters, and AG3, AG4, AG5, EL2, AM wells that expressed acidic characters.

Electrical conductivity (EC)

The EC values have a wide range as it range from 0.8 mS/cm to 33.2 mS/cm with an average 6.9 mS/cm. The average value for the Quaternary aquifer is 9.1 mS/cm, for the Pliocene aquifer is 4.2 mS/cm, for the Miocene aquifer is 30.8 mS/cm, and for the Precambrian aquifer is 3.7 mS/cm.

Redox potential (Eh)

Eh measures the tendency of the water to oxidize or to reduce dissolved constituents. The average of redox potential for the Quaternary aquifer is 559.6 mv, 559 mv for the Pliocene aquifer, and 556.5 mv for the Miocene aquifer. Precambrian water bearing aquifer recorded the highest value of Eh as it recorded 575.7 mv.

Turbidity (Ntu)

Turbidity ranges between 22.4 in AG4 to 154 in EL2, the high ratio of turbidity in EL1, EL2, EL3, and LH1 may relate to using the drilling liquid in the rotary drilling method, so these wells must be washed before using.

Dissolved oxygen (DO)

The DO in water is due to redox reaction of Fe, Mn, and Cu compounds as well as oxidation bacteria effect on the organic compounds (WHO, 1984). The higher temperature and bacteria activity are factors decrease the solubility of oxygen in water. Dissolved oxygen measurements recorded that the oxygen content ranges from 0.5 mg/l to 8.6 mg/l (GD2 and SO respectively) with an average 3.9 mg/l. The lowest amount is recorded in GD2, this may result from the bacterial activity, as the well is polluted by the livestock faeces.

Total dissolved solids (TDS)

The TDS values of the Quaternary aquifer ranges from 0.5 g/l to 9.4 g/l, for the Pliocene aquifer is 2.2 g/l, for the two wells of the Miocene aquifer is 16.9 and 2o g/l, and for the Precambrian aquifer ranges from 0.4 g/l to 5.9 g/l. The lowest value of TDS is 0.4 g/l registered in Um Ghanam well (GH) of the Precambrian rocks, and the highest value is 20 g/l registered in Abu Ghusun salty wells (AGS1).

It is obvious that Miocene aquifer registered the highest average values of TDS, and classified as saline water, the fractured basement rocks registered the lowest average of TDS and classified as brackish water except of Um Ghanam well (GH), Wadi El Gimal well (WG1), Wadi El Gimal well (WG3), and Um Soeh well (SO) that classified as fresh water, also Quaternary and Pliocene can classify as brackish water except Wadi El Ghadir Well (GD2) which classified as fresh water.

Major elements distribution

Major ions occured in concentration are ranging from 5 to 1000 mg/l. they form the bulk of the dissolved constituents in water. Four major elements were determined. These are (Ca), (Mg), (Na) and (K) (Table 3).

Distribution of Hardness

(a) Distribution of calcium (Ca^{++})

Calcium is the fifth most abundant element in the earth crust and soils, and it is readily leached out by rain water, so it is present in all surface waters at varying concentrations (Dojlido and Best 1992). Water can dissolve up to 600 mg/l calcium at ordinary room temperature from gypsum (Hem 1989 and Goldschmidt 1954).

The highest concentration of Ca in the whole area is, recorded in Abu Ghusun salty wells that related to Miocene rocks (AGS1, AGS2) 2240 and 1400 mg/l respectively, the high concentration of Ca related to presence of limestone and gypsum rocks. The lowest value of Ca content is recorded in GD2 in the middle part of wadi Ghadir, this well related to Quaternary aquifers, but it distinguishs from the other Quaternary wells by the short distance that water move to reach the well, so the bleaching of the sediments is very limited. The average content of the Quaternary aquifer is 555 mg/l, while Precambrian rocks recorded 126 mg/l.

Quaternary rocks have more concentration of Ca than the basement rocks, Most of samples (35%) of the Quaternary aquifer has Ca content ranges from 270 to 360 mg/l, as in (AG2, GD1, AM, and EL2). Most of samples (30%) of the basement aquifer have Ca content ranges from 80 to 120 mg/l, as in (LH2, LH3, LH5, LH6, RO1, RO3, HG2). Pliocene sample (LH1) has Ca content value equaled 162 mg/l. the low value of Ca attributed to the sand and shale composition of this water bearing formation. Ca content of Miocene samples (AGS1and AGS2) is 2240 and1400 mg/l respectively (Table 3).

(b) Distribution of Magnesium (Mg^{++})

The highest concentration of Mg recorded in Miocene wells (AGS1, AGS2) is 634 mg/l for each well, this may be related to leaching of dolomite and magnesite; the lowest value recorded in Um Ghanam Well (GH) reached only 32 mg/l, this attributed to the metamorphic rocks to which the aquifer related. Quaternary aquifer recorded an average 249 mg/l of Mg content, sea water encroachment leads to high magnesium concentration in the coastal wells. Basement aquifer recorded an average111 mg/l, in basement rocks, magnesium is typically a major constituent of dark Ferromagnesium minerals especially those include olivine, pyroxene, amphiboles and dark colored micas.

Quaternary samples have Mg content ranges between 50 to 100 mg/l, for (GD1, GD2, AM, and EL2), and between 200 to 250 mg/l, for (AG2, AG6, EL1, and EL3). About 25% of the basement aquifers water samples have Mg content ranges between 80 to 100 mg/l, as in (LH2, LH3, LH5, RO1, RO3, and WG3). Pliocene aquifer has Mg value equaled 179 mg/l (Table 3).

Distribution of sodium and potassium (Na^+, K^+)

The concentration of sodium in natural water is generally lesser than 200 mg/l, while it attains about 10,000 mg/l in sea water and about 25,000 mg/l in brines (Hem, 1989). Potassium concentration is much lower as compared with that of sodium. The highest value of Na recorded in the area of study is Miocene aquifer (AGS2, AGS1) 3786 and 3595 mg/l respectively. The lowest concentration of Na^+ is recorded in Um Ghanam well (GH) (67 mg/l).

About 25% of Quaternary water samples have Na^+ content ranges between 600 to 800 mg/l, as in (AG2, AG6 and AM). And 25% ranges between 1000 to 1200 mg/l, as in (AG3, EL1, and EL3), the high value of Na in Um El-Abas Wells (EL1, EL2) is attributed to presence of clay beds through the aquifer. About 30% of basement aquifers have Na content ranges from 400 to 500 mg/l, as in (LH2, LH3, LH5, TR1, TR2, HF1, and HF2). On the other hand, about 25% of samples of basement aquifers have k^+ content ranges between 2.5 to 3 mg/l as in (LH2, LH3, HE1, RO1, TR1, HG1), and 25% of samples range from 3 to 4 mg/l as in (LH5, RO3, WG1, HG2, HF1, HF2). The low ratio of K^+ in the basement rocks in relation to the quaternary rocks related to leaching of marine salts and Quaternary sediments. Pliocene aquifer recorded 4.9 mg/l for K^+ content and 352 mg/l for Na^+ content (Table 3).

Trace elements distribution

The minor constituents generally don’t dictate the chemical type of water. They have a biological behavior on groundwater quality. Although the trace elements have a low concentration they are important in limiting the use of water for certain purposes. Six minor elements were determined. These are total iron , (Cu), (Zn), (Co), (Pb), and (Mn) (Table 3).

Distribution of Iron (Fe)

The chemistry of iron in natural water is influenced by certain kinds of microorganisms (Hem, 1989). Sea water contains an average of 0.003 mg/l iron (Berner, 1970). On the other hand, river water contains a higher average content of iron (about 0.67 mg/l). Iron content in different wells varies from 0.05 to 95.33 mg/l. The aquifer system of the whole area has an average Fe concentration of 26.51 mg/l. The lowest value was recorded in Wadi Lahmi (LH1) well, and the highest one was recorded in wadi Abu Ghusun in (AG4) well, this high value may be related to presence of sand lenses reach with iron oxides. Quaternary water bearing formations contain iron content range from 11.35 to 95.33 mg/l, the Pliocene water bearing formation has 0.05 mg/l, while the Miocene water bearing formations contain from 11.68 mg/l to 16.37 mg/l, and the Precambrian water bearing formation contains from 8.98 to 60.13 mg/l (Table 3).

Distribution of Copper (Cu)

The value of copper content in different samples ranges from 0.0 to 6.7 mg/l, with an average 0.91 mg/l. Zero value was recorded in wells (GD1, LH1, LH6, and in WG3). The highest value was recorded in (RO1) well in wadi Romite, this may be related to presence of dyke rich with copper ions. The Quaternary water bearing formations contain copper content ranges from 0.0mg/l to 2.41 mg/l, the Pliocene water bearing formation recorded zero value, while the Miocene water bearing formations have from 0.45 mg/l to 0.83 mg/l, and the Precambrian water bearing formations contain from 0.0 mg/l to 6.70 mg/l (Table 3).

Distribution of Zinc (Zn)

Zinc value ranges from 0.0 mg/l to 16.41 mg/l with an average 4.71 mg/l. Zero value registered in four wells (AGS3, LH3, RO2, and SO). The highest value was recorded in AG1 well in wadi Abu Ghusun. Quaternary water bearing formations contain zinc content ranges from 8.44 mg/l to 16.41 mg/l; Pliocene water bearing formation recorded 11.69 mg/l. While the Miocene water bearing formations have from 0.0 mg/l to 3.43 mg/l, and Precambrian water bearing formations contain from 6.80 mg/l to 9.68 mg/l (Table 3).

Distribution of Cobalt (Co)

Cobalt registered the lowest average of the trace elements studied in this work 0.45 mg/l. The highest concentration registered in wadi Romite in (RO1) well. 69 % of wells registered zero value. Average of Co in Quaternary aquifers is 0.11 mg/l, and in Precambrian aquifers is 0.68 mg/l. Pliocene and Miocene recorded zero value (Table 3).

Distribution of Lead (Pb)

About two-thirds of Pb in all Pleistocene sediments has been chemically precipitated from sea water and the remainder has been transported in detrital particle (Riley and Skirrow, 1965). El-Wakeel and Riley (1961) have suggested that most Pb derived from sea water is absorbed onto the ferromanganese minerals, and the most of the remainder is located in the colloidal fractions of the sediments. The average of Pb content in different samples is 4.49 mg/l. Pb value ranges between 0.0 mg/l to 26.88 mg/l. The highest value of Pb recorded in AG4. Average of Pb in the Quaternary aquifer is 4.77 mg/l, in the Pliocene 2.45 mg/l, in the Miocene aquifer 1.78 mg/l and in the Precambrian aquifer is 4.66 mg/l (Table 3).

Distribution of Manganese (Mn)

Manganese is less abundant in the groundwater than lesser iron. It acts as soluble manganous bicarbonate, which changes to insoluble manganese hydroxide when it reacts with atmospheric oxygen. Concentration of Mn in the studied wells ranges from 0.0 mg/l to 23.28 mg/l with an average 2.73 mg/l. The highest concentration registered in Abu Ghusun well AG4; is which also registered the highest concentration of Fe, Pb, and a high concentration of Mg. Miocene water bearing formation recorded zero content of Mn, the Pliocene aquifer recorded 3.88 mg/l, the average Mn content of the Quaternary aquifers is 2.99 mg/l while for the Precambrian is 2.78 mg/ (Table 3).

Table 2: Field measurements parameters of the water samples.

Serial.	**well name**	**W.B.F**	**pH**	**Temp.**°C	**Time**	**DO** mg/l	**Eh** mv	**TDS** g/l	**EC.** mS/cm	**Tur.** Ntu
1	**AG1**	Quaternary	7.4	28	7.35 am	7	543.0	6.6	11.9	50.7
2	**AG2**	Quaternary	7.5	28	7.43 am	6.5	539.0	3.9	7.4	24.9
3	**AG3**	Quaternary	6.8	26	8.12 am	5.8	539.0	6.8	12.4	23.5
4	**AG4**	Quaternary	6.9	32	8.34 am	5.6	536.0	3.7	7.0	22.4
5	**AG5**	Quaternary	6.6	28	9.15 am	5.3	538.0	9.4	15.9	23.2
6	**AG6**	Quaternary	8.7	29	9.45 am	4.9	545.0	3.8	6.8	32.5
7	**GD1**	Quaternary	7.2	26	11.22 am	4.6	583.0	4.0	7.6	28.4
8	**GD2**	Quaternary	7.9	24	10.16 am	0.5	615.0	0.5	1.0	124
9	**AM**	Quaternary	6.9	27	11.45 pm	2.9	595.0	3.1	5.9	35.9
10	**EL1**	Quaternary	7.0	28	9.11 am	1.9	569.0	8.0	16.1	133
11	**EL2**	Quaternary	6.9	28	10.7 am	3.4	557.0	2.0	3.8	154
12	**EL3**	Quaternary	7.0	27	10.40 am	3.3	556.0	7.0	13.7	126
13	**LH1**	Pliocene	7.3	29	8.55 am	2.5	599.0	2.2	4.2	45.8
14	**AGS1**	Miocene	7.3	27	6.54 am	4	549.0	20	33.2	28.9
15	**AGS2**	Miocene	7.2	27	7.10 am	2.3	564.0	16.9	28.4	26.3
16	**LH2**	Precambrian	7.2	32	9.37 am	4.4	586	1.9	3.8	30.9
17	**LH3**	Precambrian	7.4	30	9. 53 am	1.8	608	1.9	3.8	29.6
18	**LH4**	Precambrian	7.8	29	10.15 am	3.4	592	5.9	10.9	26.3
19	**LH5**	Precambrian	7.6	32	10.35 am	2.2	597	2.1	4.0	29.0
20	**LH6**	Precambrian	7.6	32	11.10 am	1.3	607	1.7	3.0	29.3
21	**HE1**	Precambrian	7.1	29	7.27 am	2.1	607	2.9	5.2	31.6
22	**HE2**	Precambrian	7.2	30	8.15 am	2.2	598	2.8	5.1	39.7
23	**RO1**	Precambrian	7.6	28	12.15 am	5.8	544	1.4	2.8	43.2
24	**RO2**	Precambrian	7.2	30	12.34 am	4.8	551	1.3	2.6	27.0
25	**RO3**	Precambrian	7.7	33	12. 54 am	5.9	545	1.4	2.7	32.6
26	**AB**	Precambrian	7.3	30	5.10 pm	4.9	562	0.7	1.4	27.1
27	**WG1**	Precambrian	7.4	31	3.35 pm	3.9	564	3.3	6.2	31.1
28	**WG2**	Precambrian	7.5	30	4.5 pm	3.7	564	0.7	1.4	27.7
29	**WG3**	Precambrian	7.6	29	1.7 pm	4.3	556	1.3	2.6	42.7
30	**TR1**	Precambrian	7.3	27	8.57 am	2.8	597	2.1	4.0	26.6
31	**TR2**	Precambrian	7.3	29	9.17 am	0.6	614	2.2	4.1	35.7
32	**HA**	Precambrian	7.5	28	7.40 am	4.9	581	1.5	3.0	26.8
33	**HG1**	Precambrian	7.4	28	6.32 pm	4.1	568	1.6	3.0	43.3
34	**HG2**	Precambrian	7.8	26	6.19 pm	4.3	564	2	3.8	26.8
35	**HG3**	Precambrian	9.6	29	6.4 pm	4.9	561	3.3	6.3	27.6
36	**HF1**	Precambrian	7.4	27.3	7.10 pm	2.9	589	2.2	4.2	25.9
37	**HF2**	Precambrian	7.5	27.6	6.55 pm	4	578	2.29	4.4	28.3
38	**GH**	Precambrian	7.1	26	5.50 pm	2.8	580	0.4	0.8	27.6
39	**SO**	Precambrian	7.3	25	2.30 pm	8.6	527	0.9	1.8	45.6

W.B.F: Water bearing formation**,** Tem: Temperature**,** DO: Dissolved oxygen, Eh: Redox potential**,** TDS: Total dissolved solids, EC: Electric conductivity, Tur: Turbidity

Table 3: Major and trace elements concentrations in the analysed water samples.

Serial	well name	Aquifer type	W.B.F	D.method	Trace elements in ppm						Major elements (mg/l)			
					Fe	Cu	Zn	Pb	Co	Mn	Na	K	Ca	Mg
1	AG1	unconfined	Quaternary	H. dug	8.98	0.65	3.08	0.15	0.00	1.42	897	8.7	765	371
2	AG2	unconfined	Quaternary	H. dug	49.51	1.16	9.68	7.02	0.00	0.00	673	4.9	335	250
3	AG3	unconfined	Quaternary	H. dug	13.93	0.56	3.06	0.14	0.00	1.37	1035	9.2	607	508
4	AG4	unconfined	Quaternary	H. dug	49.38	1.17	9.56	6.99	0.00	0.00	592	3.2	262	307
5	AG5	unconfined	Quaternary	H. dug	9.53	0.22	3.51	4.51	0.00	0.00	1885	12.7	559	579
6	AG6	unconfined	Quaternary	H. dug	47.39	6.70	0.00	12.41	0.33	4.81	601	2.9	390	231
7	GD1	A. Deposits	Quaternary	H. dug	60.13	0.23	4.57	6.13	1.25	13.89	957	2.1	357	78
8	GD2	unconfined	Quaternary	H. dug	38.56	0.36	3.58	2.16	0.00	13.58	87	6	25	38
9	AM	A. Deposits	Quaternary	H. dug	52.79	3.62	2.35	9.36	3.58	9.14	643	2.1	357	78
10	EL1	confined	Quaternary	Rotary	14.02	0.00	2.76	0.14	0.00	0.00	1110	9.6	1540	237
11	EL2	confined	Quaternary	Rotary	11.06	1.66	4.50	4.51	0.00	0.00	312	7.8	282	75
12	EL3	confined	Quaternary	Rotary	13.92	1.19	1.30	1.09	0.00	5.22	1012	8.6	1192	237
13	LH1	confined	Pliocene	Rotary	15.10	0.00	1.99	2.91	0.00	0.72	352	4.9	162	179
14	AGS1	unconfined	Miocene	H. dug	46.59	0.76	5.56	3.79	0.00	0.96	3595	27	2240	634
15	AGS2	unconfined	Miocene	H. dug	11.71	0.57	3.81	5.17	0.00	0.00	3786	21	1400	634
16	LH2	F. P.R	Precambrian	H. dug	32.51	1.33	8.44	0.62	0.05	0.64	462	2.6	105	83
17	LH3	F. P.R	Precambrian	H. dug	0.05	0.00	11.69	2.45	0.00	3.88	452	2.6	115	83
18	LH4	F. P.R	Precambrian	H. dug	10.16	0.61	6.80	6.92	0.00	0.12	1372	4.9	437	203
19	LH5	F. P.R	Precambrian	H. dug	16.37	0.83	0.00	3.19	0.00	0.00	472	3.4	105	93
20	LH6	F. P.R	Precambrian	H. dug	11.68	0.45	3.43	0.36	0.00	0.00	301	5.4	90	153
21	HE1	F. P.R	Precambrian	H. dug	19.45	0.25	4.53	0.66	0.00	0.80	552	2.6	267	156
22	HE2	F. P.R	Precambrian	H. dug	95.33	0.95	10.35	26.88	0.82	23.28	570	5.2	267	169
23	RO1	F. P.R	Precambrian	H. dug	27.20	0.00	6.39	0.00	0.00	8.28	249	2.5	115	83
24	RO2	F. P.R	Precambrian	H. dug	11.35	0.62	4.83	5.80	0.00	0.00	342	2.1	72	77
25	RO3	F. P.R	Precambrian	H. dug	27.01	0.61	0.00	22.59	1.55	0.00	249	3.9	105	89
26	AB	F. P.R	Precambrian	H. dug	12.89	1.40	6.62	6.15	0.44	1.51	151	1.8	39	44
27	WG1	F. P.R	Precambrian	H. dug	13.49	0.31	4.37	0.13	0.00	0.35	634	3.9	242	183
28	WG2	F. P.R	Precambrian	H. dug	28.45	1.45	4.25	1.72	0.05	0.00	125	1.7	61	38
29	WG3	F. P.R	Precambrian	H. dug	20.09	0.48	7.07	5.23	0.00	0.00	298	1.2	37	87
30	TR1	F. P.R	Precambrian	H. dug	27.78	0.00	4.38	1.59	0.00	0.40	457	2.9	146	68
31	TR2	F. P.R	Precambrian	H. dug	17.12	0.63	4.20	0.00	0.00	0.06	492	1.1	173	71
32	HA	F. P.R	Precambrian	H. dug	25.57	0.50	3.45	4.60	0.63	0.31	286	2.3	67	116
33	HG1	F. P.R	Precambrian	H. dug	29.54	1.20	3.69	0.18	0.22	0.58	338	2.5	67	122
34	HG2	F. P.R	Precambrian	H. dug	27.72	0.90	3.21	0.00	0.00	0.16	382	3.7	113	145
35	HG3	F. P.R	Precambrian	H. dug	13.06	0.30	2.51	4.75	0.06	0.88	759	4.6	137	178
36	HF1	unconfined	Precambrian	H. dug	21.64	2.41	16.41	8.44	0.00	0.60	479	3.2	79	162
37	HF2	unconfined	Precambrian	H. dug	58.67	0.38	4.61	6.21	8.70	13.20	421	3.2	145	167
38	GH	unconfined	Precambrian	H. dug	25.67	0.76	3.14	0.17	0.00	0.18	67	1.9	29	32
39	SO	unconfined	Precambrian	H. dug	18.60	0.45	0.00	0.00	0.00	0.18	209	1.2	29	64
Minimum					0.045	0	0	0	0	0	67	1.1	25	32
Maximum					95.33	6.7	16.41	26.88	8.7	23.28	3786	27	2240	634
Average					26.51	0.915	4.71	4.49	0.453	2.731	709.1	5.156	346.5	182.1

Keywords:

H. dug: Hand dug wells
W.B.F: Water bearing formation
D. Method: Drilling mthod

4. Statistical analysis

Multivariate analysis of the obtained data was carried out by correlation and cluster analysis to determine associations among elements, and to objectively find groupings of similar samples along the investigated area (Figure 8). The cluster analysis of all elements results in four groups, the first group represents 22 samples, the second group 9 samples, the third group 6 samples, and the fourth group consists of 2 samples.

From the cluster it is visible that the last group which includes (AGS1, AGS2) is so different, it has the highest concentration of trace and major elements. These high concentrations might be explained by the presence of limestone and gypsum rocks.

The first group is the largest group as it includes 22 samples, the rock type of all wells in this group is basement rocks except for El2 that related to the Quaternary; this group recorded generally the lowest average values of major and trace elements except for the cobalt that recorded an average 0.529 mg/l in this group and 0.0 mg/l in the third and fourth group. The rock type of the aquifer in the first group wells is basement rocks, and all of these wells are far from the coastal plain. Therefore the presence of these high concentrations from the trace elements in the groundwater is related to the aquifer type and the wadi sediments.

Quaternary wells as Abu Ghusun wells (AG1, AG2, AG3, AG4, AG5), El Ambaout (AM) and El Ghadir well (GD1) are located in group 2 and 3. The high ratio of different elements in this group might be related to the sea water intrusion as it locates near the sea or as a result of leaching of the wadi sediments by the floods or water flow.

The high ratio of Fe, Pb, Mn, and Mg in the Quaternary aquifer of Abu Ghusun well (AG4) could be related to presence of hydrothermal solutions intrusion rich with these minerals, the hydrothermal solutions affected on the sediments as it takes brownish to reddish brown color and also affect on the water mineral content. This is considered as evidence about the lithology of the aquifer and the water mineral content.

Evaluation of groundwater quality.

The studied Marsa Alam - Baranees area has a paramount importance especially for tourist, industrial and agricultural projects. The available groundwater resources are subjected to evaluation for only livestock and agricultural purposes in the present work.

Evaluation of groundwater for livestock and poultry purposes:

The principle criteria for evaluating the water for livestock and poultry purposes are recommended by National Academy of Science (NAS, 1972). The groundwater in the study area can be classified as follow:-

a. Excellent water for all classes of livestock and poultry (TDS < 1000 mg/l), includes the groundwater of the Quaternary aquifer (water points GD2) and the Precambrian aquifers (water points AB, WG2, GH and SO).
b. Very satisfactory water for all classes of livestock and poultry (TDS ranges from 1000 to 3000 mg/l) comprises the groundwater of the following aquifers; the Quaternary aquifer (water points EL2), the Pliocene aquifer (water point LH1), and the Precambrian aquifers (water points LH2, LH3, LH5, LH6, HE1, HE2, RO1, RO2, RO3, WG3, TR1, TR2, HA, HG1, HG2, HF1 and HF2).
c. Satisfactory water for livestock (TDS ranges from 3000 to 5000 mg/l) includes the groundwater of the following aquifers; the Quaternary aquifer (water points AG2, AG4, AG6, GD1, and AM) and the Precambrian aquifers (water points WG1 and HG3).
d. Water can be used with reasonable safety for livestock and not acceptable for poultry (TDS ranges from 5000 to 7000 mg/l) includes the groundwater of the following aquifers; the Quaternary aquifer (water point AG1, AG3 and EL3) and the Precambrian aquifers water points LH4.
e. Water can not be used for poultry and probably for some livestock (TDS ranges from 7000 to 10,000 mg/l). it includes the groundwater of the Quaternary aquifer (water point AG5 and EL1). The other water that can not be used under any conditions (TDS > 10,000 mg/l) occurs in the Miocene aquifer (water point AGS1 and AGS2).

Evaluation of groundwater for irrigation purposes.

Considering the quality of groundwater and their suitability for irrigation purposes, the following factors are taken into consideration:-

1- The total concentration of soluble salts (TDS).
2- The relative proportion of Sodium to other cations (SAR).
3- The concentration of certain minor elements that may be toxic to plants.

Two methods are used to evaluate the suitability of groundwater for irrigation purposes. They comprise the following:

Salinity

Based on the EC, irrigation water can be classified into four categories (College of Agricultural Sciences, 2002) (Table 4 and Figure 9).

Sodium hazard:

The main problem with high sodium concentration is its effect on soil permeability and water infiltration. Sodium also contributes directly to the total salinity of the water and may be toxic to sensitive crops.

Continuous use of water having a high SAR leads to a breakdown in the physical structure of the soil. The sodium replaces calcium and magnesium sorbet on clay minerals and causes dispersion of soil particles. This dispersion results in breakdown of soil aggregates and causes a cementation of the soil under drying conditions as well as preventing infiltration of rain water.

Three samples are related to S2 as GD1, AGS1, and HG3. One sample related to S4. The rest of the samples belonged to S1 group.

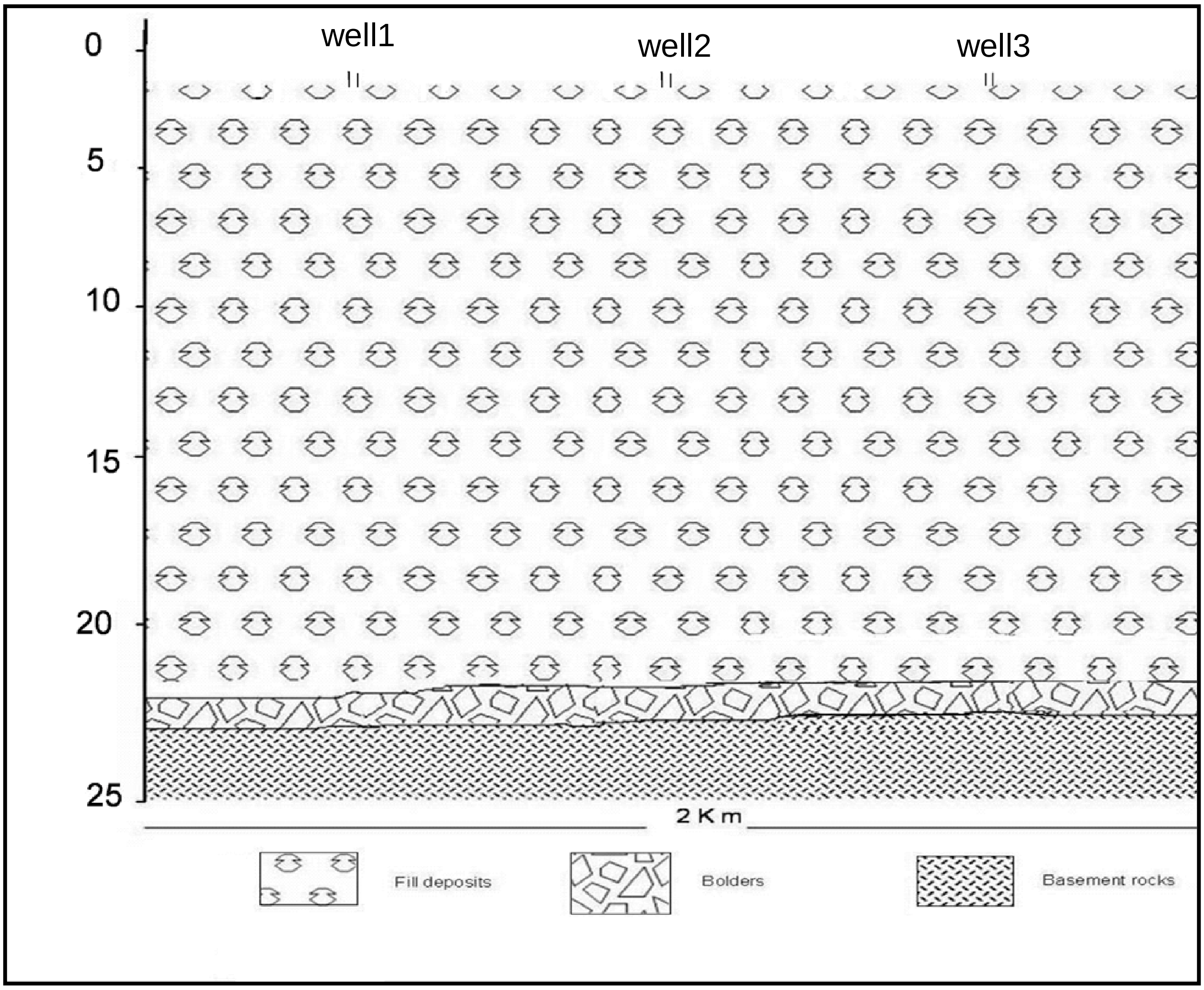


Figure 7: Lithologic section of Um Heglega wells.

Cluster-1

Cluster-2

Cluster-3

Cluster-4

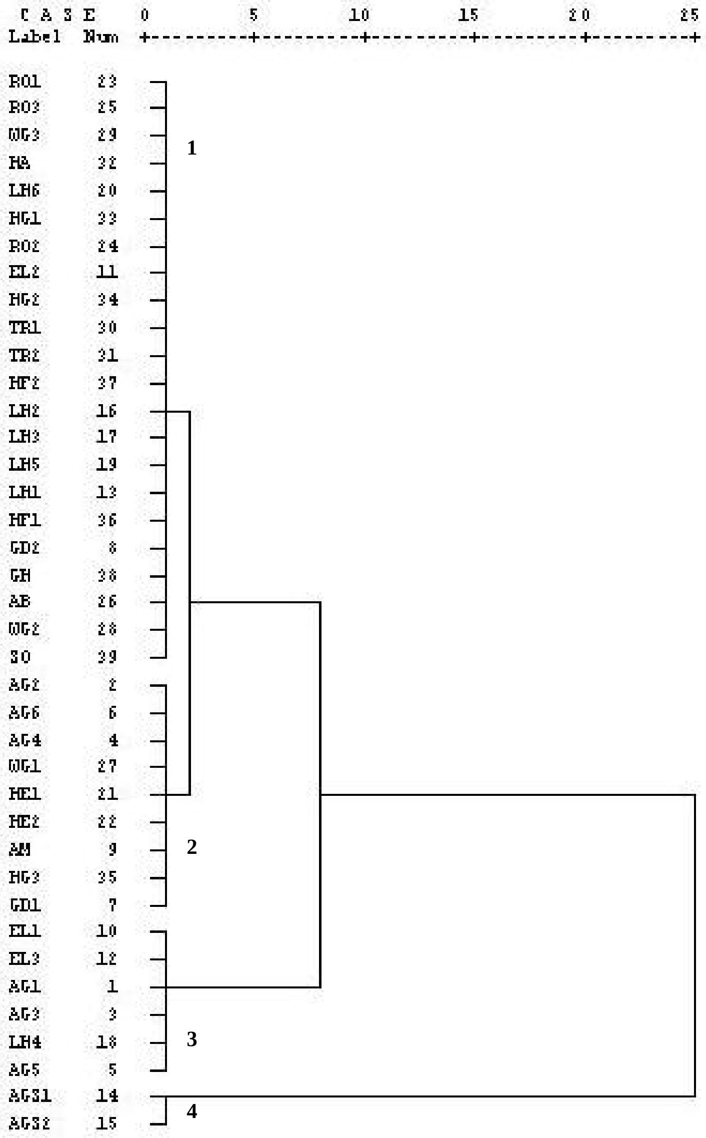


Figure 8: Cluster analysis for the whole elements (Ward method).

Table 4: Water samples classification based on salinity (EC) values.

Level	points Water
(C1) Low	Quaternary water points (GD2), Precambrian water points (AB, WG2, GH and SO)
(C2) Medium	Quaternary water points (AG2, AG4, AG6, AM and EL2),) Pliocene water point (LH1), all Precambrian water points except (AB, WG2, GH, SO and LH4)
(C3) High	Quaternary water points (AG1, AG3, AG5, GD1, EL1 and EL3)
(C4) Very high	Miocene water points (AGS1 andAGS2)

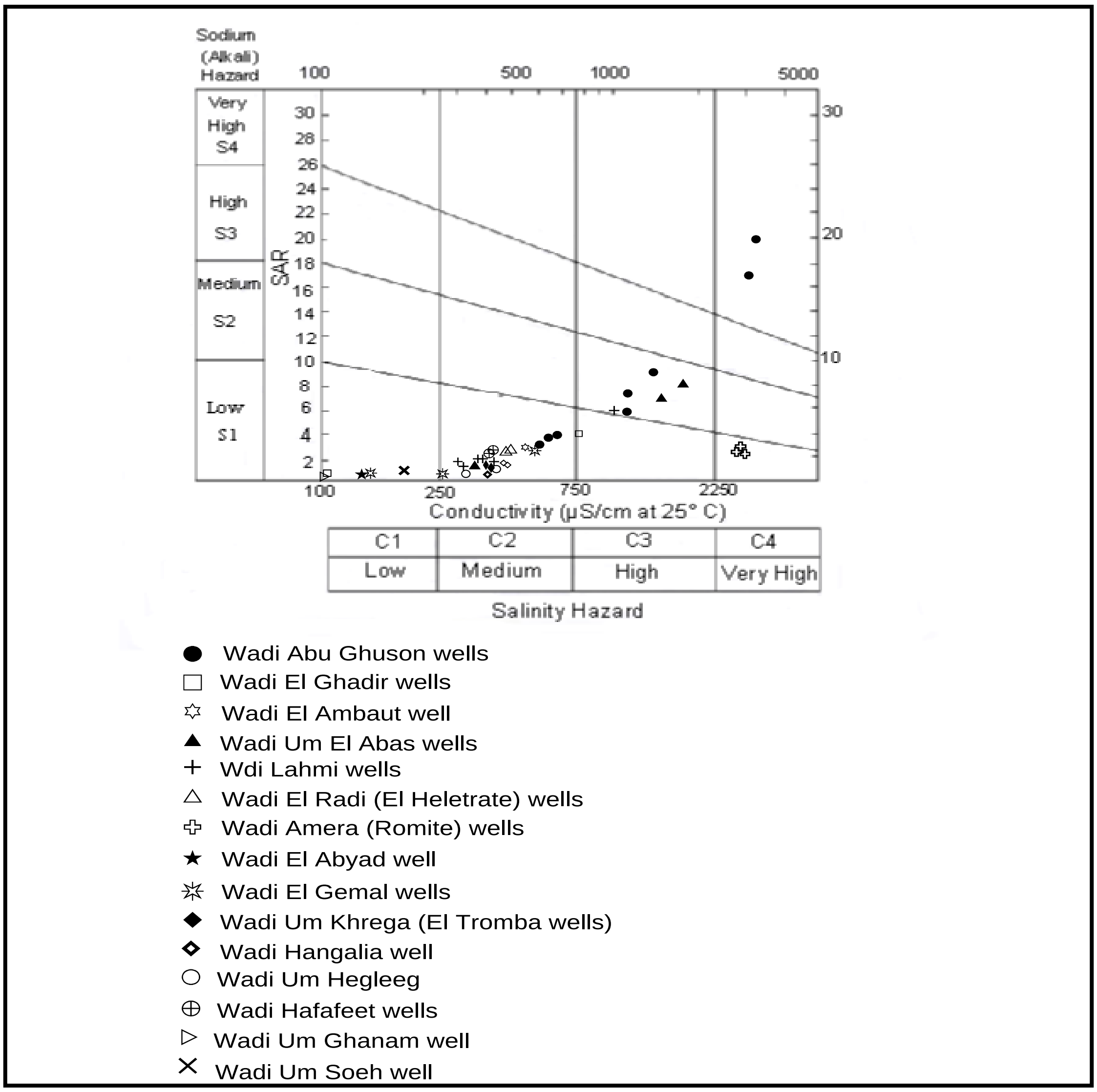


Figure 9: Wilcox diagram explain the sodium hazard (Wilcox, 1948).

5. Summary and conclusion

Groundwater samples were collected from the available water points representing the defined aquifers. The total number of samples is 39 samples. Among them; 12 samples represent the Quaternary aquifer, 1 sample represents the Pliocene aquifer, 2 samples represent the Miocene aquifer, and 24 samples represent the Precambrian aquifer.

The results of water samples analysis and the interpretation concluded from cluster analysis emphasis that there is a great relation between the rock type and the water characteristics. From our study we concluded that the highest concentration of trace and major elements salts located in the Miocene rocks, the lowest average values of major and trace elements recorded in the basement rocks and in the Quaternary rocks the ratio ranges between high and low depending on the leaching of the wadi sediments and sometimes as a result of sea water effect. From the results it is visible that the highest concentration of trace and major elements in the underground water samples of different wells might be explained by the presence of limestone and gypsum rocks as in AGS1, AGS2 wells or it might be related to the sea water intrusion as it locates near the sea or as a result of leaching of the wadi sediments by the floods or water flow as in the Abu Ghusun wells. The lowest concentration of trace and major elements except for the cobalt in most wells as in Lahmi and Romite wells is related to the basement rocks of the aquifer in these wells, and all of these wells are far from the coastal plain so the water type related to the aquifer type and the wadi sediments. The available groundwater resources are subjected to evaluation for only livestock and agricultural purposes in the present work.

REFERENCES

Abd El-Samie, S., Ewais M. Moussa., and Mohamed A. Sayed.: 2006, "hydrochemical and isotopic characteristics of the groundwater in central and south Eastern Desert, Egypt" *Sedimentology of Egypt*. Vol. 14. p 83-94.

Berner, R.: 1970, "Abundance in natural waters" Wedepohl, K. H. (Extensive Edit.), Handbook of geochemistry, Sprenger Verlag, Berlin.

Clifford, T.N.: 1970, The structural framework of Africa. In: T. N. Clifford and I. G. Grass (eds) *African magmatism and tectonics*. Edinburgh: Oliver and Boyd, p. 1.

College of Agriculture Sciences: 2002, Irrigation water quality. The Pennsylvania State University, USA. (http://www.cas.psu.edu/docs/casdept/Turf/Education/Turgeon/CaseStudy/Oldranch/IrrWatQual.html, 14.05.2002).

Dojlido, J. and Best, G.A.: 1992, "Chemistry of water and water pollution". Ellis Horwood series in water and wastewater technology. New Yourk-London.

Egyptian mineral resources authority EMRA: 2005, Unpuplished report for the tourism development authority "Appendix report of the second stage of mechanical drilling" p 1-27.

El-Wakeel, S.K., and Riley., J.P.: 1961, Chemical and mineralogical studies of deep-see sediments. Geochim. et cosmoch. *Acta,* 25: p.110-146.

Geologic map of Egypt: 1997, Egyptian mineral resources authority "Egyptian geologic survey before" for the area between Marsa Alam to Baranees, scale 1: 250,000. Cairo, Egypt.

Goldschmidt V.H.: 1954, "Geochemistry Edited by Alex Muir". Clarendon press, Oxford, England.

Hem, J.D.: 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 3rd ed., 263 p.

Hem J.D.: 1989, "Study and interpretation of chemical characteristics of natural water". U.S. Geological Survey, Water supply, paper 1473 and 2254 p. 264.

National Academy of Science (NAS), and National Academy of Engineering (NAE): 1972, Water quality criteria, Protection Agency Washington, D.C., pp 1- 594.

Riley, J.P., and Skirrow, G.: 1965, Chemical oceanography. Academic Press, London, 508 p.

Robert, G. Coleman: 1993, Geologic evolution of the Red Sea, Oxford university press, Inc. 186 pp.

Robinson, G.R.: 1997, Portraying chemical properties of bedrock for water quality and ecosystem analysis: an approach for the New England Region, U.S. Geological Survey Open-File Report 97-154, 18 p.

Rogers, R.J.: 1989, Geochemical comparison of ground water in areas of New England, New York, and Pennsylvania: *Ground Water*, v. 27, p. 690-712.

Stacey, J.S., and Hedge, C.E.: 1984, Geochronological and isotopic evidence for early proterozoic crust in eastern Arabian shield. *Geology* 12, 310 p.

Wilcox, L.V.: 1948, The quality of water for irrigation use. U.S. Dept. *Agric. Techn. Bull*. 962, pp. 1-40.

World Health Organization (WHO): 1984, Guideline for drinking water quality. Geneva, pp. 1-50.

دراسات جيولوجية و جيوكيمائية على خصائص المياه الجوفية فى المنطقة الواقعة ما بين مدينتى مرسى علم و برانيس ، البحر الأحمر، مصــر

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-3 قطاع محميات البحر الأحمر

تهدف هذه الدراسة إلى دراسة خصائص المياه الجوفية فى المنطقة الواقعة ما بين مدينتى مرسى علم و برانيس ، البحر الأحمر، مصــر وذلك من خلال جمع 39 عينة من مياه الآبار الموجودة بالمنطقة ولقد تم تحديد إحداثيات هذه الآبار وتوقيع أماكنها على الخريطة الجيولوجية بواسطة جهاز GPS كما تم قياس الخصائص الطبيعية لعينات المياه مباشرة فى الحقل بواسطة جهاز الهيدرولاب وذلك لمعرفة درجة جودتها وكذلك تم قياس العناصر السائدة مثل (Na, K, Ca, and Mg) وأيضا العناصر الثقيلة مثل (Mn, Cu, Zn, Pb, Co, and Fe) وذلك بمعامل المعهد القومى لعلوم البحار و المصايد. ولقد أظهرت النتائج و التحليلات الرياضية التراكمية التجمعية إلى وجود علاقة مباشرة بين خصائص المياه وطبيعة ونوع الصخور الحاوية لها حيث تبين أن العناصر السائدة و الثقيلة تتواجد بنسب عالية فى عينات المياه الجوفية التى تتواجد فى صخور الميوسيين فى حين نجد أن العناصر السائدة و الثقيلة تتواجد بنسب منخفضة فى عينات المياه الجوفية التى تتواجد فى صخور المعقدات (Basement Rock) فى حين أننا نجد أنه فى حالة صخور الحقب الرباعى تعتمد نسب تواجد العناصر السائدة و الثقيلة ما بين الزيادة و النقصان على مدى مكرر تأثر هذه الصخور بتداخل مياه البحر حسب قربها وبعدها منه أو تأثرها برواسب الوديان القادمة مع السيول و الفيضانات التى تؤثر على المنطقة.هذه الدراسة تعطينا معرفة لطبيعة و جيوكيميائية تلك المياه و مدى درجة التلوث بالمواد الثقيلة. لذلك تلك البيانات سوف تساعد المسئولين فى تحديد استخدامتها وكذلك تحديد الآثار السلبية لها على لانسان و التقييم الأمثل لعلاج و حل المشكلات الناتجة عن ذلك و كذلك التنبؤ بأى تغيير فى النتائج الحالية و الذى يمكن رصده خلال الأنشطة التى سوف تتم فى المستقبل حيث أثبتت تلك النتائج أن هذه المياه تمثل مخزون حى وطبيعى للمياه التى يمكن استخدامها فى اغراض الزراعة.