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Hedrogeological Studies on Wadi El-Farigh Area, West Nile Delta, Egypt

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ABSTRACT

The present study deals will deal with the evaluation of groundwater potentiality by using Hydrogeological and Hydrochemical investigation tools. The area of study is located south of Wadi El-Natron depression, southwest of the Nile Delta and left the Cairo – Alexandria Desert Road. It extends in a WNW-ESE direction for about 90 km with an average width of about 10 km. As calculated by the present author Wadi El-Farigh depression has a catchment area of 1112.5 km2 enclosed between the contours of 120 m above sea level in the south and west and 4 m below sea level in north center part. It lies between latitudes 30º 00' 00'' and 30º 30' 00'' N and Longitudes 30º 00' 00'' to 30º 50' 00'', E. The area includes lands belonging to the two governorates of Behira and Giza. The low area of wadi El-Farigh depression is dominated by sand accumulation and rock fragment. The aquifer system is belonging to Moghra (Lower Miocene) and the analyzed water samples of the investigated area show fresh to brackish water. The T.D.S. for the analyzed water samples ranges from 252 ppm to 2572 ppm. The depth to water in Miocene aquifer varies from 49 m at the area close to El Rayah El Naseri to 176.88 m at high topographic areas towards the west. The total salinity of the Miocene aquifer (Moghra aquifer) varies from fresh to slightly brackish water.

Keywords: Groundwater-Aquifer- Nile Delta.

I. INTRODUCTION

The areas under investigation occupy a portion of the Western Nile Delta region (Fig. 1). It lies between latitudes 30º 00' 00'' and 30º 30' 00'' N and Longitudes 30º 00' 00'' to 30º 50' 00'', E. It is considered as a depression of low relief (El-Tahrir gravel plan, Wadi El-Natron depression and Wadi El-Farigh Depression).

The available studies are dealt with the geomorphology, geology, hydrogeology, hydrology and hydrogeochemistry. Shata (1947), (1953), and (1962), El Fayoumy (1967), Attia (1975) (1982), Picard (1955), Said (1962), Seanad (1973) & Omara and Sanad (1975), El Shazly et al., (1975), General Petroleum Company "GPC" (1977, El Ghazawi and Atwa, 1994), El-Abd (2005), Shafeek (2015).

Figure 1. Location of the study area

The study of climatic conditions is of paramount importance for the study of geomorphological elements due to the impact of climate on the composition of the external factors. The current study is based on weather station wadi El-Natrun as the nearest weather station for the wadi El-Farigh depression.

- The average annual temperature of 21.5 ° C and the average ranges between 17.3 ºC for the winter months and 25 ºC for the summer months, suggesting that depression moderate climate in winter and hot in summer.
- Average annual wind speed (17.7 km / h), and this rate ranges between (16.3 km / h), and winter (19.1 km / h) for the summer and recorded the highest speed of the wind during the year in the month of April (21.1 km / h), while the lowest speed of the wind in the month of January and December (15 km / h)
- The annual average relative humidity in the wadi El-Farigh depression 55%, ranging from 58% for the winter months and 52% for the summer months.
- The monthly rate of evaporation ranges between 5.2 mm / day (average month of January), and 14.1 mm /day (average month of June), and up the annual rate of evaporation of 9.4 mm day.
- The annual average for the Rainfall that falls on the depression 3.5 mm. this quantity is of great significance to the emergence of depression and wadi El- Farigh, and suggest that the depression has arisen under moist conditions in ancient times was more rainfall than it is now, and maybe it happened in the Middle Miocene.
- These aridity index results indicate typical desert conditions for the study area. Form all the main Hydrometeorology finding we can conclude that the study area is characterized by a hyper- arid climate.

II. Regional Geomorphology

The area under consideration is of Depression and low relief (El-Tahrir gravel plan, Wadi El- Natrun depression and Wadi El-Farigh Depression). The general land surface slopes gently to the northern and eastern directions. Landforms are classified into 3 geomorphic units (Fig. 1.2). These geomorphic units from north to south are:

The alluvial plains: The alluvial plains constitute one of the most striking land features in the study area. These plains extend between Rosetta branch and the eastern fringes of MaryuIt tableland. They are classified into young and old alluvial plains.

The structural plains: The structural plains occupy a wide area to the south and west of the old alluvial plain. It consists of a number of alternating structural ridges and structural depressions, reflecting the impacts of both the Lithologic and structural factors. Old gravel surface stretch for a long distance on the gentle slopes of the structural plain as well as the escarpment bounding Wadi El Farigh on the northern side. They are classified into structural ridges and structural depressions.

The shifting sand: Drift sands and sand sheets cover wide portions of the old alluvial plains and the lowest parts of the large depressions. Also there are a series of long, narrow parallel elongate sand dunes known as El Heneishat sand dune chains. These chains extend southwards till the northern periphery of El Faiyum depression.

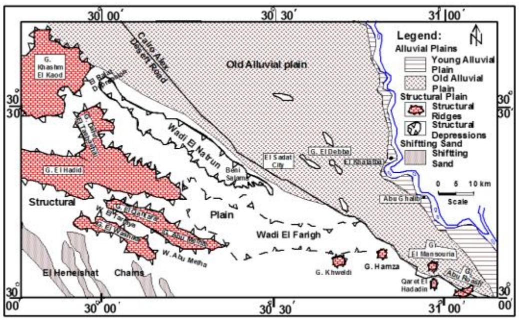


Figure 2. Geomorphologic map of west Nile Delta, Egypt, (Compiled after different authors).

III. Stratigraphy

The study area is covered by extensive sedimentary exposures ranging in age from Late Cretaceous to Quaternary. In subsurface the sedimentary section has a thickness of about 4000 m resting on the basement rocks. The Late Cretaceous sediments have a localized occurrence on the crest of the complicated folded structure to the west of El Giza (Abu Rawoash anticline). Eocene and Oligocene sediments are of limited distribution in the environs of Cairo (Fig. 3) and (Fig.4).

Miocene sediment: Miocene sediment is represented by El Moghra Formation, which covers the south and west of Wadi El Natrun and the area from Wadi El Farigh in the east to El Qattara depression in the west. In Wadi El Farigh the thickness of Miocene sediments is about 150 m, which is rapidly increases to about 900 m in the northwest direction, and the facies of Miocene become more marine in that direction. Moghra Formation is mainly composed of coarse sands, sandstone and clay interbeds with vertebrate remains and silicified wood, which becomes gravelly at base. The concerned formation rests unconformable on basalt sheets in several localities at surface as well as in the subsurface. Basalt sheets are located at levels ranges from –767 m below mean sea level at the southwest of Wadi El Natrun to 158 above mean sea level at Qaret El Haddadin. It located at depths ranges from ground surface to 839 m. They are located at different levels due to the effect of many faults in the form of horst-like and graben-like structures. Miocene lithfacies are Sandy gravel, gravelly sand, slightly gravelly sand and sand. Environments of deposition are different all over the Miocene aquifer from turbidity currents, fluvial and beach. The fluvial environments are the dominant environments.

The heavy minerals assemblage of El Moghra sediments have been recycled from older sediments which supplies the highly stable detritus (ZTR) and high metamorphic and acid igneous rocks of the basement rocks of the Eastern Desert mountains through the Eonile river tributaries which drained the Red Sea mountains during the Miocene period

Pliocene sediments: Pliocene sediments have a wide distribution in Wadi El Natrun depression and its vicinities; it is divided from base to top into Wadi El Natron Formation and El Hagif Formation. Wadi El Natrun Formation is classified into Muluk and El Solimaniya Members.

Muluk Member is composed of dark grey clays with sand beds intercalation and restricted to the inner portion of Wadi El Natrun with exposed thickness of about 25 m at Quart El Muluk (type locality). However, the subsurface succession is composed of pyretic dark grey clays alternating with sand beds.

El Solymanya Member is composed of light green sand and sandstone alternating with shelly limestone and it is restricted to the periphery of Wadi El Natrun. It has 30 thick at Ras El Solymanya (type locality).

El Hagif Formation is mainly composed of thick white limestone beds intercalated with argillaceous sequence and it is restricted to the west of Wadi El Natrun depression. The thickness of El Hagif Formation ranges between 30 m and 40 m.

Quaternary deposits: Quaternary deposits cover wide stretches of the study area and it distinguished into different types as deltaic deposits and crust, alluvial deposits, lagoonal deposits, salt marshes and sabkha and Aeolian deposits. The thickness of the Quaternary sediments varies from 350 m to 25 m, it increases in the areas close to delta and decreases in the area close to Wadi El Natrun. Lithfacies of the Quaternary sediments are Sandy gravel, gravelly sand, slightly gravelly sand and sand. The lithofacies of the Quaternary sediments varies laterally and vertically and it has a direct impact on its hydraulic parameters. The environments of deposition are different all over the Quaternary sediments from turbidity currents, fluvial and beach. The fluvial environment is the dominant.

Structure: Folds, faults, unconformities and basaltic intrusions mainly affect the area of study. These types of structural elements are the most important factors controlling the groundwater conditions.

Folds: The area of study is mainly affected by two fold systems.

-The NE-SW folds' system (Syrian Arcs); the most conspicuous fold is Abu Roash domal structure.

-The NW-SE (clysmic) folds system; the most conspicuous folds are Wadi El Farigh and Wadi El Natrun anticlinal structure.

Faults systems: The study area is mainly affected by three normal faults systems. These systems in decreasing order of abundance are as follows:

- NW-SE (Clysmic) system
- NE-SW (Aqaba) system.
- E-W (Tethys) system.

The investigated area is separated from the Delta basin by one or more step faults having an eastern downthrown. Such faults are responsible for the facing of highly permeable Quaternary deposits of the Nile Delta with older sediments due west, and consequently, a westward flow of the Nile water to the western old sediments. Also, an important principle fault trending in a NW-SE, running approximately parallel to Rosetta branch is strongly expected to separate the Delta basin from the area to the west.

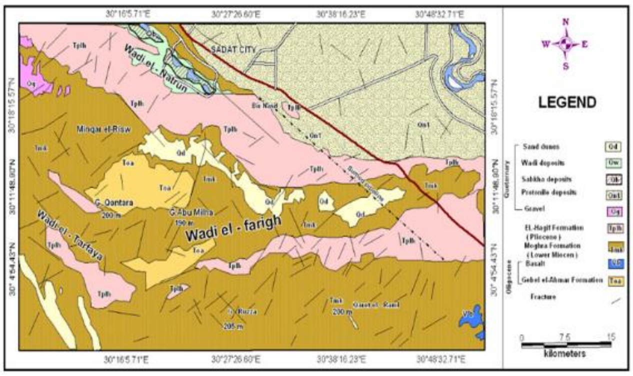


Figure 3. Geologic map of west Nile Delta, Egypt, (Conoco, 1987).

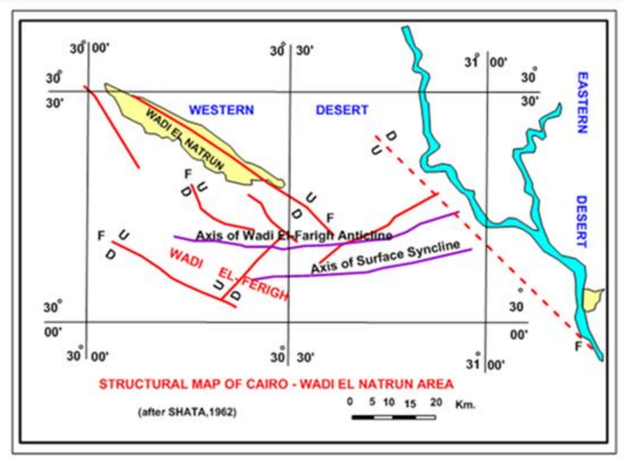


Figure 4. Structural map of Cairo-wadi El-Natrun area after (Shata, 1962).

IV. The Hydrogeological Setting

From the hydrogeological point of view, special emphasis is given to the following topics:

Surface water system: The surface water system is mainly Rosetta branch, El Rayah El Beheri, El Rayah El Nasseri and smaller canals. Such water system is subjected to infiltration to the groundwater aquifers. The canals are cutting the Nile silt and sandy clay deposits, discharging their water into the cultivated land.

Groundwater aquifers: The groundwater in the study area is mainly controlled by the geological conditions including lithology and geological structures. The main water bearing formations in the study area are:

- The Quaternary aquifer
- The Pliocene aquifer
- The Lower Miocene aquifer (Moghra), and
- The Oligocene aquifer

Miocene aquifer covers a wide area south and southwest of Wadi El Natrun and it is mainly composed of coarse sands and clay lenses intercalation (Fig. 5). The saturated thickness of the Lower Miocene aquifer varies from 741 m in the western portion, 179 at K52 east Cairo-Alex. Desert Road and 16 m at Gebel Khashm El Kalb. Miocene aquifer has been deposited on the basaltic sheet at different levels; in the form of horst and graben-like structures. The amount of groundwater stored in Miocene aquifer is about $25.9X10^9$ m^3 and the amount of withdrawal which equals the drawdown in groundwater is about $0.036X10^9$ m^3/year. This aquifer is under artesian conditions in the east and changes to water table aquifer towards the west. In Wadi El Natrun depression, where this aquifer is overlain by impervious Pliocene clay, the groundwater exists under confined condition. The ground water level in the Miocene aquifer varies between +8 m at the border with the Nile delta Quaternary aquifer to about –22.1 at the west. The high groundwater extraction allows the formation of the depression cones of pizometric levels. Isotopes indicate that the main recharging sources for the Miocene aquifer are old Nile water (before the construction of the High Dam) and small contribution of the recent Nile water in the area beside El Rayah El Nasseri. The estimated C^{14} age is 16737 YBP. The old age confirms the presence of ancient recharge component accompanying the recent one.

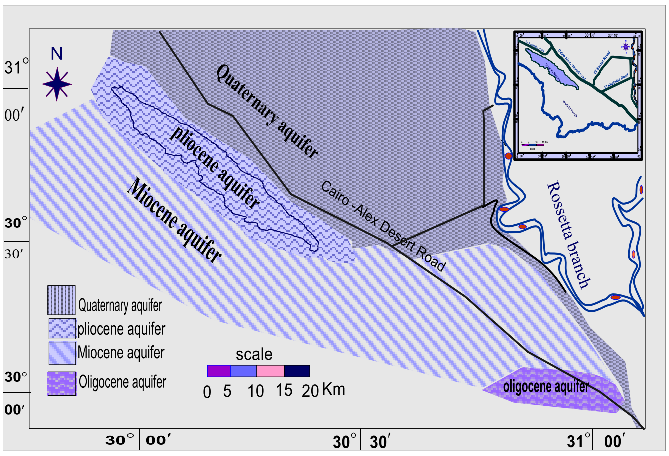


Figure 5. Distribution of different aquifers in the west Nile Delta area.

The total thickness of the Miocene sediments is varying from 75 m in the northeastern portion to about 250 m at Wadi - El Natron, Regionally this thickness increases in northwest direction (El Ghazawi and Attwa, 1994). The saturated thickness of the Miocene aquifer (fig 6) is controlled by the prevailing structural conditions in the area. The maximum saturated thickness attains about 169m, and thins out in the northeastern direction to reach about 27 m at the Khasm El Kalb area.

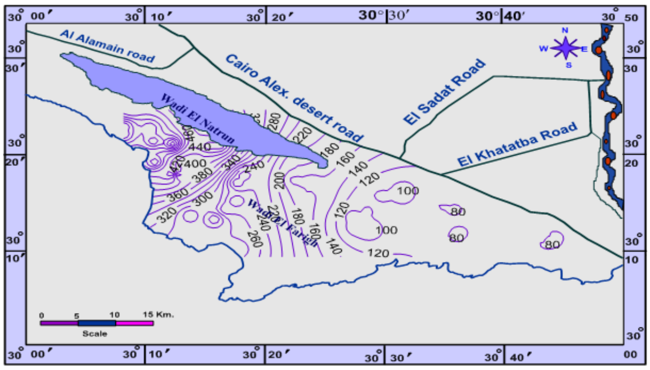


Figure 6. Saturated thickness contour map of the Miocene aquifer after Shafeek (2015).

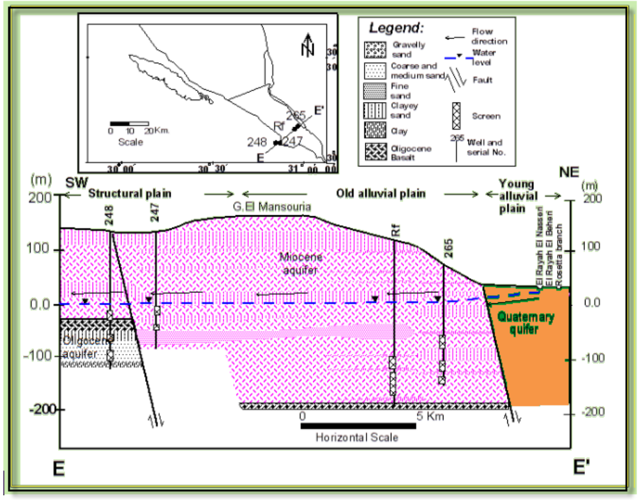


Figure 7. Hydrogeological Cross Section E-E' after Al Abd (2005).

The southeastern boundaries of the lower Miocene aquifer are delimited by a set of faults with downthrows to the north where the Oligocene basaltic sheet is highly elevated (from + 150 m to + 30 m) above the regional potentiometric surface of the Lower Miocene aquifer (+2 m) (Fig. 7) accordingly, this aquifer is hydraulically connected with the underlying Oligocene aquifer. The northern boundary of Lower Miocene aquifer is bounded by many faults. South Wadi El Natron, this aquifer is bounded by NW- SE faults with their down throwing sides to the east where the Lower Miocene is uplifted in the front of the Pliocene aquifer.

The depth to water in Miocene aquifer varies from 49 m at the area close to El Rayah El Naseri to 176.88 m at high topographic areas towards the west (Fig. 8). The groundwater level in the Miocene aquifer varies between +6 m at the border with the Nile delta Quaternary aquifer to about –33.8 at the west. The ground water level at El Qattara depression is about –60 m below sea level accordingly, the groundwater flows to the west (El Qattara depression) with hydraulic gradient of about 20 cm/km (Hefny, et al, 1991). The groundwater in the Miocene aquifer flows westward. through Wadi El Farigh (Fig. 9). This movement is mainly controlled by an old burried Nile channels which divert groundwater flow towards Wadi El Natrun depression. There are two other groundwater flow directions one from the northeast (from Quaternary to Lower Miocene) and the second from southeast. High extraction rate along Cairo-Alexandria desert road and Wadi El Farigh allow the formation of the cones of depressions with high hydraulic gradient.

The total amount of groundwater recharge from the Nile Delta aquifer is estimated to be in the rang of 50 to 100x10^6 m^3/year (RIGW/IWACO, 1990b). The amount of recharge was estimated using groundwater model as 84x10^6 m^3/year (Diab, et al. 1992). The discharge of this aquifer is mainly through the extraction from wells and is relatively discharged into the Pliocene aquifer at the southern part of Wadi El Natrun (Gomaa, 1995). High extraction rate (20-30x10^6 m^3/year/Km^2) was found along Cairo-Alexandria desert road (El Fakharany, 1998). The extraction of large volumes of groundwater allow the formation of cones of the depressions of pizometric levels. Since the extraction rate are still increasing the lowering of water level and will continue in the future (RIGW/IWACO, 1990b). The environmental isotopes indicate that the main recharging source for the Miocene aquifer is the old Nile water before the construction of the High Dam with few contribution from recent Nile water in the area beside El Rayah El Naseri. The estimated age using C^{14} is 16737 YBP (Dahab et al., 1998) confirming the dominance of ancient recharge component.

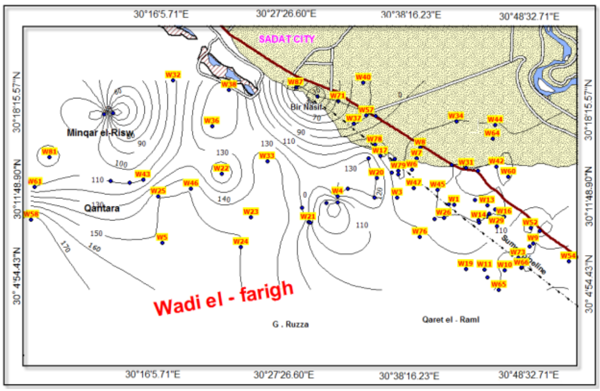


Figure 4. Depth to Water Contour Map of the Miocene Aquifer (2015).

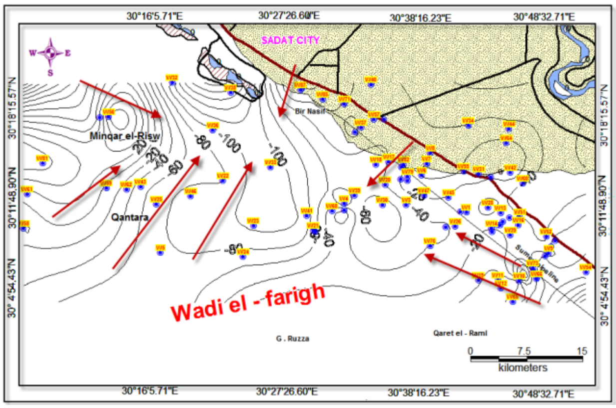


Figure 9. flow net map of the Miocene Aquifer

V. Hydrochemical

The chemical composition of groundwater also reflects the ecosystem function, so that it is important to detect any changes resulting from natural systems and or caused by development processes. For the assessment of the chemical composition of the groundwater in the study areas 46 water samples from 46 water points were collected from wadi El-Farigh as showing as Fig. (10).
The total salinity of the Miocene aquifer (Moghra aquifer) varies from fresh to slightly brackish water. Local anomalies in water salinity are detected at the area East Cairo-Alex desert road, west El Rayiah El Nasseri and southwest Wadi El Natrun due to the over pumping rates, the presence of shallow clay lenses within the water bearing layers especially west El Rayiah El Nasseri and the low groundwater recharge. The total salinity ranges between 252 ppm and 2572 ppm. In Wadi El-Farigh the pH values vary from 7.11 to 8.5. All PH values of the selected water samples lie in the range of alkalinity.

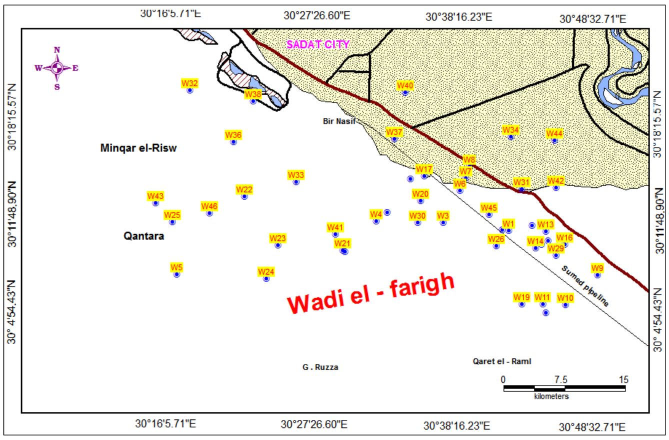


Figure 10. Groundwater samples location map.

The hypothetical salt combinations of selected water samples are distinguished into six main assemblages as shown in Figures (11). Palmar (1911) as follows:

- **Group 1**: (Na+K) Cl, MgCl2, CaCl2, CaSO4, Ca (HCO3)2. (Samples No. w1 and w9).
- **Group 2**: (Na+K) Cl, (Na+K) SO4, MgSO4, Mg (HCO3)2, Ca (HCO3)2. (Samples No. w2, w6, w8, w13, w32, w34 and w46).
- **Group3**:(Na+K)Cl,(Na+K)SO4,(Na+K)HCO3,Mg(HCO3)2,Ca(HCO3)2.(SamplesNo.w3,w4,w7,w14,w15,w16,w17,w18,w19,w26,w27,w28,w29,w30,w31,w33,w36,w37,w38,w39,w40,w42,w43,w44,and w45).
- **Group4**: (Na+K) Cl, MgCl2, MgSO4, CaSO4, Ca (HCO3)2. (Samples No. w5, w10, w11, w21, w22, w24 and w35).
- **Group5**:(Na+K)Cl,(Na+K)SO4,MgSO4,CaSO4,Ca(HCO3)2.(SamplesNo.w12and w41).
- **Group6**:(Na+K)Cl,MgCl2,MgSO4,Mg(HCO3)2,Ca(HCO3)2.(SamplesNo.w20,w23and w25). w23and w25).

Figure 11. Palmer diagram showing the hypothetical salt combination of the analyzed samples no. (1-46).

Hydrochemical Classification Using Sunil's Diagram (1946show that four water types represent the water samples of Moghra Aquifer as shown in Figure (12). These are discussed hereinafter.

A – The **Na2SO4** water type is a mixed water of meteoric genesis it is represented by samples nos. (2, 6, 8,12,13,29,32,35,41 and 46) where (rNa/rCl) > 1 and (rNa/rK) - rCl/ rSo_4< 1, which reflect the hydrochemical composition if water samples and the hypothetical salt combination of this water and the hypothetical salt Combinations of this water are (Na+K) Cl, (Na+K) SO4, MgSO4, Mg (HCO3)2, Ca (HCO3)2. These hypothetical salt combinations represent a chemical formation of infiltrating water of meteoric genesis.
B – The **NaHCO3** water type water of meteoric water is represented by samples nos. (3,4,7,14,15,16,17,18,19,20,26,27,28,30,31,33,34,36,

37,38,39,40,42,43,44 and 45). These samples are characterized by (rNa/rCl) > 1 and (rNa/rK) - rCl/ rSo_4 >1 which reflect a meteoric origin.

C - The **CaCl2** water type is represented by two water samples nos. **(**1, 9) where (rNa/rCl) < 1and rCl - (rNa/rK) / rMg > .1This reflects an old marine origin. That is confirmed by the higher salinity of the two samples of about 1895 ppm.

D **-** The **$MgCl_2$** water type is represented by rest of the water samples which are characterized by the ratio of (rNa/rCl) < 1and rCl - (rNa/rK) / rMg < 1 .These water reflect a marine water origin. Their hypothetical salt combinations are (Na+K) Cl, $MgCl_2$, $MgSO_4$, Mg $(HCO3)_2$ and Ca $(HCO3)_2$. These salts represent the chemical formation of normal composition of sea water.

According to the U.S. Laboratory Salinity diagram (1954), the groundwater samples of Moghra aquifer system are of low sodium hazard and fall in the fields C_2-S_1 and C_3-$S_{1,}$ where S_1 is low sodium water, C_2 is moderate salinity water which is good for soils of medium permeability for most plants, and other sample lies in the C_3-$S_{2,}$ C_4-$S_{2,}$ C_3-$S_{3,}$ C_4-$S_3$and C_4-S_4 field. From Classified as groundwater in terms of sodium absorption ratio method U.S. Laboratory Salinity diagram (1954), it clear that the samples lie near the medium salinity water, which is satisfactory for plants having moderate salt tolerance on soils of moderate permeability with leaching. The samples fall in fields C_3-$S_{3,}$ C4-$S_3$and C_4-S_4 high to vary high sodium hazard and salinity water. Figures (13),

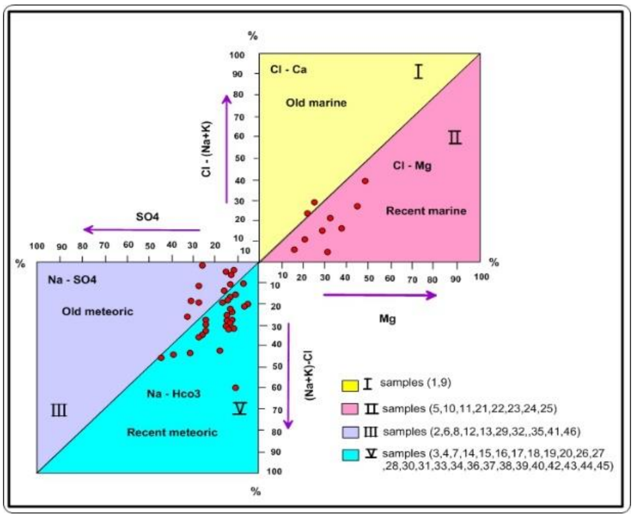


Figure 12. Sulin's graph for genetic classification of the groundwater samples of the Moghra aquifer.

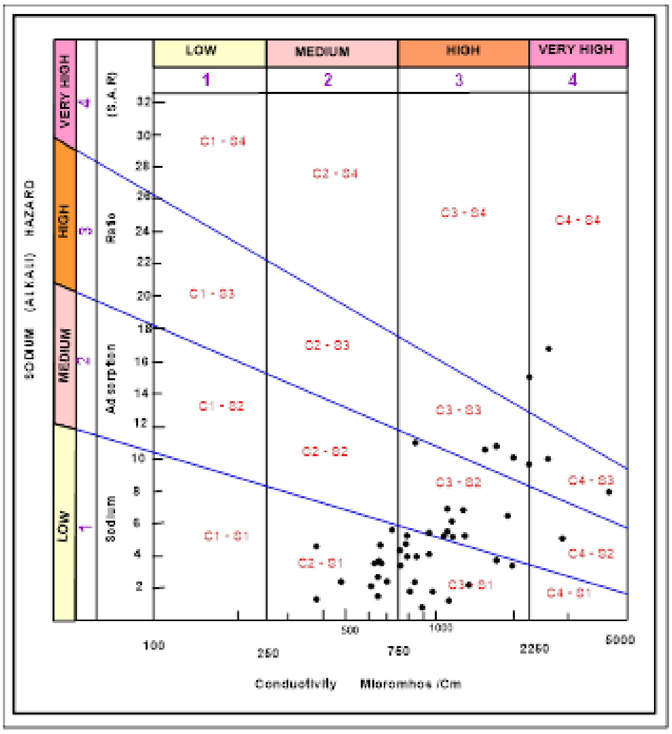
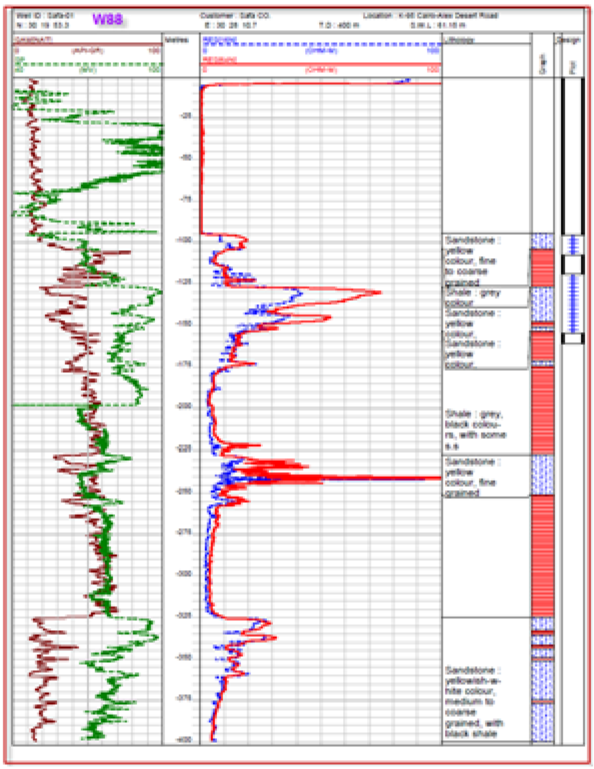
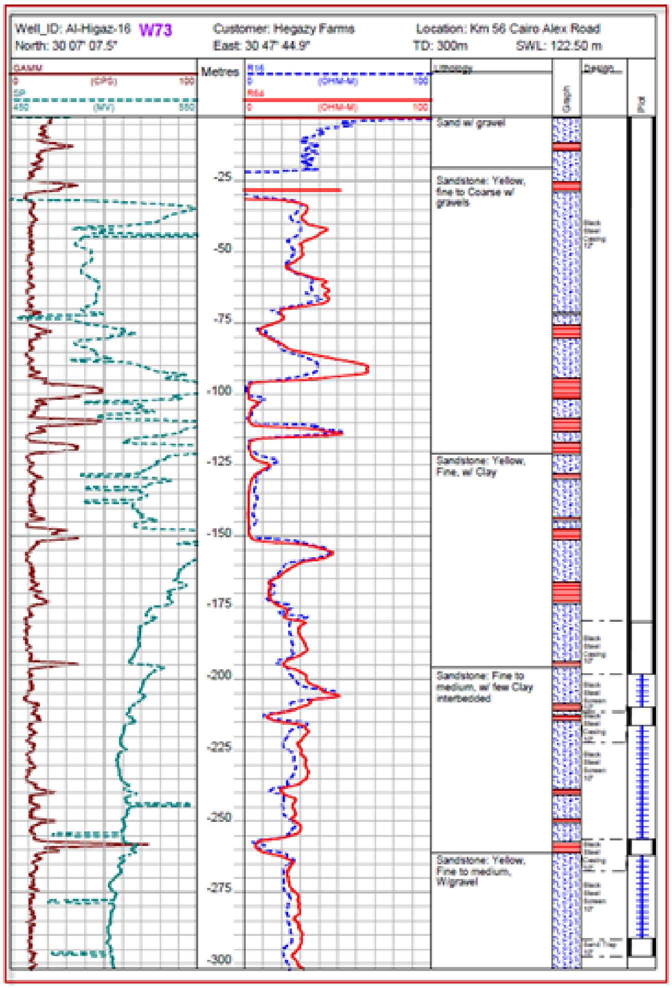


Figure (13): Diagram for use in interpreting the analysis of irrigation water. Adapted from U.S. Laboratory Salinity staff (1954).





well No.	T.D.S ppm	E.C mmohs/cm	PH	Units	Cations K+	Na+	Ca++	Mg++	Sum.	Anions HCo3⁻	Cl⁻	So4⁻	Sum.	S.A.R Epm	Ht. ppm	R.S.C Epm
				Eq.w.	39.1	22.99	20.04	12.16		61.02	35.45	48.03				
				ppm	10.2	315	142.75	87		87	750.2	216			713.575	
w1	1895	2960	8.5	Epm	0.26087	13.70161	7.123253	7.154605	28.24034	1.425762	21.1622	4.497189	27.08515	5.128083		-12.8521
				e %	0.923748	48.51787	25.22368	25.3347		5.263999	78.13211	16.60389				
				ppm	4.9	180	49	23		175	244	85			216.8	
w2	779	1217	8.41	Epm	0.12532	7.829491	2.44511	1.891447	12.29137	2.867912	6.882934	1.769727	11.52057	5.317114		-1.46864
				e %	1.019575	63.6991	19.8929	15.38842		24.89383	59.74472	15.36145				
				ppm	6.6	134	46.51	18		257	144	79			190.075	
w3	618	965	8	Epm	0.168798	5.828621	2.320858	1.480263	9.798541	4.211734	4.062059	1.644805	9.918598	4.227902		0.410612
				e %	1.722685	59.48458	23.68575	15.10698		42.46299	40.95396	16.58304				
				ppm	2.3	123.5	21.33	9.42		190	114.8	48			91.947	
w4	463	724	7.94	Epm	0.058824	5.371901	1.064371	0.774671	7.269767	3.113733	3.238364	0.999375	7.351472	5.602052		1.274691
				e %	0.809153	73.89372	14.64106	10.65606		42.35523	44.05055	13.59422				
				ppm	4.5	275	75	35		200	468	116			331	
w5	1209	1889	7.8	Epm	0.11509	11.96172	3.742515	2.878289	18.69762	3.277614	13.20169	2.415157	18.89446	6.574358		-3.34319
				e %	0.61553	63.97458	20.016	15.39388		17.34695	69.87069	12.78235				
				ppm	3.4	170	34.8	26		185	240.8	58			193.6	
w6	721	1126	7.94	Epm	0.086957	7.394519	1.736527	2.138158	11.35616	3.031793	6.792666	1.207579	11.03204	5.312596		-0.84289
				e %	0.765721	65.11461	15.2915	18.82818		27.48171	61.57218	10.94611				
				ppm	3.5	119.1	36.89	16.23		220	142	43.5			158.768	
w7	538	840	8.01	Epm	0.089514	5.180513	1.840818	1.334704	8.44555	3.605375	4.005642	0.905684	8.516701	4.11131		0.429853
				e %	1.059896	61.34016	21.79631	15.80364		42.333	47.03279	10.63421				
				ppm	3.7	54.4	33.36	11.08		151	68	31.9			128.828	
w8	326	509	8.06	Epm	0.094629	2.366246	1.664671	0.911184	5.03673	2.474598	1.918195	0.664168	5.056961	2.085039		-0.10126
				e %	1.878782	46.97981	33.05062	18.09079		48.93449	37.93176	13.13374				
				ppm	9.9	185	125	50		136	430	181			517.5	
w9	1174	1836	8.1	Epm	0.253197	8.046977	6.237525	4.111842	18.64954	2.228777	12.12976	3.768478	18.12702	3.537454		-8.12059
				e %	1.357658	43.14839	33.446	22.04795		12.29534	66.91537	20.78929				
				ppm	4.9	70	53.73	30		156	155	62			257.325	
w10	536	837	7.94	Epm	0.12532	3.044802	2.681138	2.467105	8.318365	2.556539	4.372355	1.29086	8.219754	1.897774		-2.5917
				e %	1.506542	36.60337	32.23155	29.65854		31.10238	53.19326	15.70436				

well No.	T.D.S ppm	E.C mmohs/cm	PH	Units	Cations K+	Na+	Ca++	Mg++	Sum.	Anions HCo3⁻	Cl⁻	So4⁻	Sum.	S.A.R Epm	Ht. ppm	R.S.C Epm
				Eq.w.	39.1	22.99	20.04	12.16		61.02	35.45	48.03				
				ppm	7.7	187	153.34	50		190	368	293			588.35	
W11	1299	2030	7.9	Epm	0.196931	8.133971	7.651697	4.111842	20.09444	3.113733	10.38082	6.100354	19.59491	3.353889		-8.64981
				e %	0.980027	40.47871	38.07867	20.46259		15.89052	52.97713	31.13235				
				ppm	4.2	196.9	62.39	19.53		161	245	170			236.048	
W12	893	1391	7.97	Epm	0.107417	8.564593	3.113273	1.606086	13.39137	2.638479	6.911142	3.539455	13.08908	5.575454		-2.08088
				e %	0.802135	63.95607	23.24836	11.99344		20.15787	52.80084	27.04129				
				ppm	3.5	56	40	24		223	75	40.6			198.4	
W13	420	657	8.01	Epm	0.089514	2.435842	1.996008	1.973684	6.495048	3.654539	2.115656	0.845305	6.6155	1.728963		-0.31515
				e %	1.378189	37.50306	30.73123	30.38752		55.24207	31.98028	12.77764				
				ppm	7	124	33.68	10.72		238	102.3	54.8			128.152	
W14	506	790	7.94	Epm	0.179028	5.393649	1.680639	0.881579	8.134895	3.900361	2.885755	1.140954	7.927069	4.765294		1.338143
				e %	2.200743	66.30263	20.65962	10.837		49.20306	36.4038	14.39313				
				ppm	6	110	29.66	8.58		213	91.4	38.7			109.328	
W15	433	677	8	Epm	0.153453	4.784689	1.48004	0.705592	7.123774	3.490659	2.578279	0.805746	6.874684	4.576992		1.305027
				e %	2.154093	67.16509	20.77607	9.904752		50.77555	37.50397	11.72049				
				ppm	8	118	34.91	11.36		234	103.7	52.8			133.851	
W16	492	769	7.97	Epm	0.204604	5.132666	1.742016	0.934211	8.013496	3.834808	2.925247	1.099313	7.859368	4.437073		1.158582
				e %	2.553237	64.05027	21.73853	11.65796		48.79283	37.21987	13.98729				
				ppm	6	96	31.66	10.58		209	82.86	44.5			122.528	
W17	428	668	8.06	Epm	0.153453	4.175729	1.57984	0.870066	6.779087	3.425107	2.337377	0.926504	6.688987	3.772876		0.9752
				e %	2.263619	61.59721	23.30462	12.83456		51.20516	34.94365	13.85119				
				ppm	11	204	51.7	16.44		263	241.3	78.6			196.654	
W18	816	1274	7.97	Epm	0.28133	8.873423	2.57984	1.351974	13.08657	4.310062	6.80677	1.636477	12.75331	6.32863		0.378248
				e %	2.149761	67.80558	19.71365	10.331		33.79564	53.37258	12.83178				
				ppm	4.7	176	45.71	19.24		263	196.1	74.8			193.159	
W19	763	1192	7.98	Epm	0.120205	7.655502	2.280938	1.582237	11.63888	4.310062	5.531735	1.55736	11.39916	5.508286		0.446887
				e %	1.032785	65.77524	19.59757	13.59441		37.81036	48.52758	13.66206				
				ppm	5.2	45	63	43		138	41	35			333.8	
W20	252	399	8.17	Epm	0.132992	1.957373	3.143713	3.536184	8.770262	2.261554	1.156559	0.728711	4.146823	1.071035		-4.41834
				e %	1.516401	22.31829	35.84514	40.32017		54.53701	27.89023	17.57276				

well No.	T.D.S ppm	E.C Micromohs/cm	PH	Units	Cations K+	Na+	Ca++	Mg++	Sum.	Anions HCo3⁻	Cl⁻	So4⁻	Sum.	S.A.R Epm	Ht. ppm	R.S.C Epm
				Eq.w.	39.1	22.99	20.04	12.16		61.02	35.45	48.03				
				ppm	11.73	114.4902	80.3604	53.6256		242.8696	287.854	76.848			420.766	
W21	876.8	1370	7.75	Epm	0.3	4.98	4.01	4.41	13.7	3.98	8.12	1.6	13.7	2.427103		-4.44
				e %	2.189781	36.35036	29.27007	32.18978		29.05109	59.27007	11.67883				
				ppm	7.82	75.867	46.2924	31.4944		183.6702	147.1175	83.5722			244.858	
W22	569.6	890	7.9	Epm	0.2	3.3	2.31	2.59	8.4	3.01	4.15	1.74	8.9	2.108293		-1.89
				e %	2.380952	39.28571	27.5	30.83333		33.82022	46.62921	19.55056				
				ppm	7.429	54.2564	70.5408	59.9488		245.3004	194.975	71.0844			422.1421	
W23	704	1100	7.59	Epm	0.19	2.36	3.52	4.93	11	4.02	5.5	1.48	11	1.14815		-4.43
				e %	1.727273	21.45455	32	44.81818		36.54545	50	13.45455				
				ppm	8.211	35.4046	59.7192	54.3552		183.06	188.2395	42.7467			372.1543	
W24	588.8	920	7.12	Epm	0.21	1.54	2.98	4.47	9.2	3	5.31	0.89	9.2	0.797917		-4.45
				e %	2.282609	16.73913	32.3913	48.58696		32.6087	57.71739	9.673913				
				ppm	13.685	74.7175	60.12	47.424		236.1474	188.594	62.9193			344.7384	
W25	672	1050	7.87	Epm	0.35	3.25	3	3.9	10.5	3.87	5.32	1.31	10.5	1.749741		-3.03
				e %	3.333333	30.95238	28.57143	37.14286		36.85714	50.66667	12.47619				
				ppm	5.5	100	40	14.6		252	92	56			159.86	
W26	490	650	7.6	Epm	0.140665	4.349717	1.996008	1.200658	7.687048	4.129794	2.595205	1.165938	7.890936	3.440546		0.933128
G.5				e %	1.829896	56.58501	25.96686	15.61923		52.33591	32.88842	14.77566				
				ppm	7	110	38	16		270	95	50			160.6	
W27	500	665	7.4	Epm	0.179028	4.784689	1.896208	1.315789	8.175714	4.424779	2.679831	1.041016	8.145626	3.775558		1.212782
Tpw3				e %	2.189755	58.52319	23.19317	16.09388		54.32092	32.89902	12.78006				
				ppm	7	90	46	25		340	83	20			217.5	
W28	530	700	7.7	Epm	0.179028	3.914746	2.295409	2.055921	8.445104	5.571944	2.341326	0.416406	8.329676	2.65404		1.220613
Pw48				e %	2.119904	46.35521	27.18035	24.34453		66.89268	28.10825	4.999071				
				ppm	5.9	113.5	32.86	27		239	133	66.4			192.85	
W29	600	760	7.7	Epm	0.150895	4.936929	1.639721	2.220395	8.94794	3.916749	3.751763	1.382469	9.050981	3.553626		0.056633
Pw15				e %	1.686367	55.17392	18.32512	24.81469		43.2743	41.45145	15.27426				
				ppm	2.1	128	34.3	23.4		294	124.1	56.7			181.69	
W30	620	800	7.3	Epm	0.053708	5.567638	1.711577	1.924342	9.257265	4.818092	3.500705	1.180512	9.49931	4.129323		1.182173
Tpw2				e %	0.580176	60.14344	18.48901	20.78737		50.72045	36.85221	12.42735				
				ppm	2	194.7	4	10.83		218.3	156	81.2			54.403	
W31	650	850	7.5	Epm	0.051151	8.4689	0.199601	0.890625	9.610276	3.577516	4.400564	1.69061	9.66869	11.47054		2.48729
Wk3				e %	0.532252	88.12337	2.076952	9.267424		37.00104	45.51355	17.48541				

well No.	T.D.S ppm	E.C mmohs/cm	PH	Units	Cations K+	Na+	Ca++	Mg++	Sum.	Anions HCo3⁻	Cl⁻	So4⁻	Sum.	S.A.R Epm	Ht. ppm	R.S.C Epm
				Eq.w.	39.1	22.99	20.04	12.16		61.02	35.45	48.03				
				ppm	4	382	60	28		214	419	288			264.8	
W32	1394	2010	7.78	Epm	0.102302	16.61592	2.994012	2.302632	22.01487	3.507047	11.81946	5.996252	21.32276	10.21031		-1.7896
				e %	0.464694	75.47591	13.59996	10.45944		16.44743	55.4312	28.12137				
				ppm	6	300	44	9		275	265	190			146.9	
W33	1088	1590	7.9	Epm	0.153453	13.04915	2.195609	0.740132	16.13834	4.506719	7.475317	3.955861	15.9379	10.77056		1.570979
				e %	0.950858	80.85806	13.60492	4.586168		28.27675	46.90278	24.82047				
				ppm	7	66	28	22		195	89	24			160.2	
W34	431	610	7.9	Epm	0.179028	2.870813	1.397206	1.809211	6.256258	3.195674	2.510578	0.499688	6.20594	2.267305		-0.01074
				e %	2.861585	45.88707	22.33293	28.91841		51.49379	40.45444	8.051765				
				ppm	6	598	184	77		232	923	552			775.7	
W35	2572	4000	7.53	Epm	0.153453	26.01131	9.181637	6.332237	41.67864	3.802032	26.03667	11.49282	41.33152	9.339359		-11.7118
				e %	0.368181	62.40922	22.0296	15.193		9.198868	62.99471	27.80642				
				ppm	9	315	16	30		214	213	361			163	
W36	1158	1700	7.81	Epm	0.230179	13.70161	0.798403	2.467105	17.1973	3.507047	6.008463	7.516136	17.03165	10.72287		0.241538
				e %	1.338461	79.67304	4.642609	14.34589		20.59136	35.27823	44.13042				
				ppm	3	138	46	15		183	42	89			176.5	
W37	515	430	8.15	Epm	0.076726	6.00261	2.295409	1.233553	9.608298	2.999017	1.184767	1.853009	6.036793	4.518889		-0.52995
				e %	0.798542	62.47319	23.88986	12.83841		49.67898	19.62577	30.69525				
				ppm	9	442	20	27		342	330	360			160.7	
W38	1530	2250	8.07	Epm	0.230179	19.22575	0.998004	2.220395	22.67433	5.60472	9.308886	7.495315	22.40892	15.15578		2.386321
				e %	1.015153	84.79083	4.401471	9.792549		25.01111	41.54098	33.44791				
				ppm	5	222	37	28		306	195	161			207.3	
W39	954	1320	8.1	Epm	0.127877	9.656372	1.846307	2.302632	13.93319	5.014749	5.500705	3.352072	13.86753	6.704409		0.86581
				e %	0.917789	69.30483	13.25115	16.52624		36.16182	39.66609	24.1721				
				ppm	7	138	32	13		171	178	29			133.3	
W40	567	800	7.91	Epm	0.179028	6.00261	1.596806	1.069079	8.847523	2.80236	5.021157	0.603789	8.427306	5.199174		0.136475
				e %	2.023483	67.84509	18.04806	12.08337		33.25333	59.58199	7.164678				
				ppm	9	467	100	24		214	533	398			348.4	
W41	1744	2630	7.11	Epm	0.230179	20.31318	4.99002	1.973684	27.50706	3.507047	15.03526	8.286488	26.8288	10.88611		-3.45666
				e %	0.8368	73.84714	18.14087	7.175191		13.07195	56.04151	30.88654				
				ppm	8	156	38	12		191	138	106			144.2	
W42	648	950	8.14	Epm	0.204604	6.785559	1.896208	0.986842	9.873212	3.130121	3.892807	2.206954	9.229882	5.651641		0.247072
				e %	2.07231	68.72696	19.20558	9.995147		33.91291	42.17613	23.91097				
				ppm	9	495	35	18		325	433	322			161.3	
W43	1636	2430	8.01	Epm	0.230179	21.5311	1.746507	1.480263	24.98805	5.326123	12.21439	6.704143	24.24465	16.95107		2.099352
				e %	0.921156	86.16559	6.989369	5.923884		21.96824	50.37971	27.65205				
				ppm	4	77	42	14		256	70	19			162.4	
W44	487	660	8.05	Epm	0.102302	3.349282	2.095808	1.151316	6.698708	4.195346	1.974612	0.395586	6.565544	2.628556		0.948222
				e %	1.527187	49.99893	31.28675	17.18713		63.89944	30.07538	6.025184				
				ppm	9	196	35	16		246	161	136			153.1	
W45	799	1170	8.19	Epm	0.230179	8.525446	1.746507	1.315789	11.81792	4.031465	4.541608	2.831564	11.40464	6.88983		0.969169
				e %	1.947712	72.13998	14.77846	11.13385		35.34935	39.82247	24.82818				
				ppm	6	389	50	36		244	391	347			272.6	
W46	1462	2220	7.79	Epm	0.153453	16.9204	2.49501	2.960526	22.52939	3.998689	11.02962	7.224651	22.25296	10.24488		-1.45685
				e %	0.681122	75.10368	11.07447	13.14073		17.96925	49.56473	32.46602				

VI. Conclusion

The ground water in wadi El- Farigh is available from an aquifer system belonging to Lower Miocene times (Moghra aquifer.). The total thickness of the Miocene sediments is varying from 75 m in the northeastern portion to about 250 m at Wadi - El Natron, Regionally this thickness increases in northwest direction The depth to water in Miocene aquifer varies from 49 m at the area close to El Rayah El Naseri to 176.88 m at high topographic areas towards the west The groundwater in the Miocene aquifer flows westward. through Wadi El Farigh. This movement is mainly controlled by an old buried Nile channels which divert groundwater flow towards Wadi El Natron depression.

The total salinity of the Miocene aquifer (Moghra aquifer) varies from fresh to slightly brackish water. The total salinity ranges between 252 ppm and 2572 ppm. In Wadi El-Farigh the pH values varies from 7.11 to 8.5. All PH values of the selected water samples lie in the range of alkalinity.

According to the U.S. Laboratory Salinity diagram, the groundwater samples of Moghra aquifer system are of low sodium hazard and fall in the fields C_2-S_1 and C_3-S_1, where S_1 is low sodium water, C_2 is moderate salinity water which is good for soils of medium permeability for most plants, and other sample lies in the C_3-S_2, C_4-S_2, C_3-S_3, C_4-$S_3$and C_4-S_4 field. From Classified as groundwater in terms of sodium absorption ratio U.S. Laboratory Salinity diagram clear that the samples lie near the medium salinity water, which is satisfactory for plants having moderate salt tolerance on soils of moderate permeability with leaching. The samples fall in fields C_3-S_3, C4-$S_3$and C_4-S_4 high to vary high sodium hazard and salinity water.

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