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EVALUATION OF GROUND WATER QUALITY AND SUITABILITY FOR DIFFERENT USES IN EL- KHARGA, EL- DAKHLA AND EL- FARAFRA OASES, WESTERN DESERT, EGYPT

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ABSTRACT: *Groundwater is the main source of domestic, industrial and agriculture uses in most of El- Kharga, Dakhla and Farafra Oases in the Western Desert of Egypt, which affected the groundwater quality. The hydrochemistry of major ions (Na^+,K^+, Mg^{+2}, Ca^{+2}, Cl^-, $SO4^{2-}$, HCO_3^-, and CO_3^{2-}) together with trace elements (Fe and Mn) has been used to constrain the hydrochemical characteristics of groundwater, Western Desert of Egypt aquifers. The present study focuses on*

1- Hydrochemical characterization of the ground water

2- Origin of the groundwater

3- Evaluation of the groundwater suitability for different purposes.

The obtain results reveal that the electrical conductivity varied from 0.187 (Bir Mut) and 1.25 dS/m (Bir Teneida).The regional salinity distribution shows increasing salinities towards El-Kharga Oasis. The total dissolved salts (TDS) are 112 ppm for Bir Mut and 768 ppm for Bir Teneida. The studied groundwater samples is slightly acid to strongly alkaline where pH values varied from 6.1 to 8.7. SAR values characterized by excellent water suitable for irrigation, where RSC values indicate a good quality and suitable for using irrigation. The calcium (Ca^{+2}), sodium (Na^+), magnesium (Mg^{+2}) and potassium (K^+) ions aquire the higher concentrations of the cations, while bicarbonate (HCO_3^-), chloride (Cl^-) and sulfate (SO_4^{2-}) ions aquire the higher concentrations of the anions. The concentrations of the major cations and anions are lower than the maximum standard limits, while Fe and Mn ions are higher than the standard limits (WHO 1984). Hydrochemical coefficient (Ion ratios) are also useful in detecting the origin of the groundwater. These ratios are

($rNa^+ + rK^+/Cl^-$), $\frac{rSO4=}{rCl,}$, $\frac{rCl-}{r(HCO3-+CO3=)}$ & $\left(\frac{rSO4=}{r\,anions}-\frac{nr\,Na-}{r\,cations}\right)\times 100$

Results of these ratios indicate that the groundwater have a mixed origin that is possibly pure meteoric water affected to a less extent by traces of marine faces. The evaluation of groundwater in El- Kharga, El- Dakhla and El- Farafra Oases for general uses indicate that these waters are not suitable for drinking usage, while these water are excellent for classes of livestock, poultry and moderately and marginally suitable for irrigation crops.

Key words: *Groundwater, Origin, Kharga, Dakhla, Farafra, aquifers, Hydrochemical*

INTRODUCTION

Expansion and development of the concerned desert area are based essentially on groundwater resources for drinking and irrigation. Since the Nubian aquifer is the main source of groundwater in the Western Desert of Egypt. The recent information available on the Western Desert reveals that the groundwater horizons of the Western Desert constitute just small scattered portions within an extensive multi-layer "Artesian Basin" that covers nearly the whole Tertiary of the Libyan Desert, Western Desert to the east of the Nile Valley, Northern regions of Sudan and the North-eastern territories of Chad. This basin was given the name Nubian Artesian Basin, Himida & Diab (1981) and Heinal & Thorweihe (1993). The Nubian basin system in Egypt is formed of Pre- Tertiary sediments: The eastern boundaries of Nubian basin can be delineated by the series of mountain ranges consisting of basement rocks and extending parallel to the Red Sea Coast. Its western boundaries cannot be sharply defined but they can be tentatively traced along the localities where rocks of basement complex either outcrop on the surface or recorded at shallow depth. Its Southern boundaries can be defined by the outcrops of basement rocks in different regions of North Sudan and in the Northeastern regions of the Chad. According to Thorweihe, (1990), The water aquifer area in Egypt could be classified into three structural units (Map1).

1- North Western basin

2- Dakhla basin

3- Upper Nile platform

The North Western basin, extends to the North of Cairo – Bahariya uplift and is included within the unstable shelf, this basin of minor economic importance within the structure of the Nubian aquifer system.

The Dakhla basin, is the largest and most important unit in the Western Desert of Egypt. The Southern part of the Dakhla basin is filled mainly with fine to coarse grained continental sandstone of lower Cretaceous to Cenomenian age, and reach up to 1000 m. in thickness. These sediments pile formerly called Nubian Sandston is intercalated by two regional formation of low permeability. These are the marine Abu Ballas formation (Barthel & Bottcher 1978). Which is formed by a few 10 m. of poorly permeable shale increasing in thickness toward the North, and the deltaic to shallow marine Maghrabi formation (Barthel & Hermann- Degen, 1981). Which reaches up to 200 m. in thickness and is formed by inter – bedded shale and sandstone with fair permeability. In the Northern part of the Dakhla basin, the cretaceores sediments overlie. Paleozoic sediments and are covered by variegated shale (Mut formation, Barthel & Herman – Degen, 1981) and the Dakhla formation (Said 2000), which reaches up to 100 m. in thickness and forms the confined bed of Nubian aquifer system. The upper Nile platform, is situated East of Dakhla basin and is separated form it by the kharga uplift which strikes from basement outcrop of Bir Safsaf towards North to El-Kharga the area of upper Nile platform was high, thus no sediments of lower Cretaceous to Cenomenian age were deposited. Thus the area becomes a shallow basin and was filled approximately 500 m. of sediments with much higher rate of shale than those of Dakhla basin. So upper Cretaceous sediments of the upper Nile platform have a much lower permeability than their equivalent in the Dakhla basin. Northward, the effect of the Kharga uplift decreases and the differentiation into Dakhla basin and upper Nile platform is not possible north of Kharga.

The objective of this study is to through light on the hydrochemistry of the Nubian faces in the Western Desert area and determine the chemical type of groundwater and their relation to prevailing hydrogeological and environmental conditions and evaluate the suitability of groundwater for different uses.

MATERIALS AND METHODS

Based on the obtained topographic map scale 1: 100.000 and the geological map of scale 1:100.000, twenty four wells and springs groundwater samples were collected to represent the study area. The locations of the wells and springs from which the samples were obtained are shown in Fig. (1). The type of sampling bottles and their cleaning methods are important. Polyethylene bottles were soaked in 1.5 ml. nitric acid for about 48 hours at room temperature in order to remove all leachable cations of heavy metals. The bottles were washed with distilled water for at least four times. Water samples were stored in bottles treated in this manner at 4^{o} over periods of week. The bottles were closed tightly, Keep in ice – boxes and transferred at low temperature to the laboratory. Before the analyses of the water samples, the filtration step was carried out using 0.45-um membrane filters to removes the colloidal particles and undissolved metals from the ground water samples.

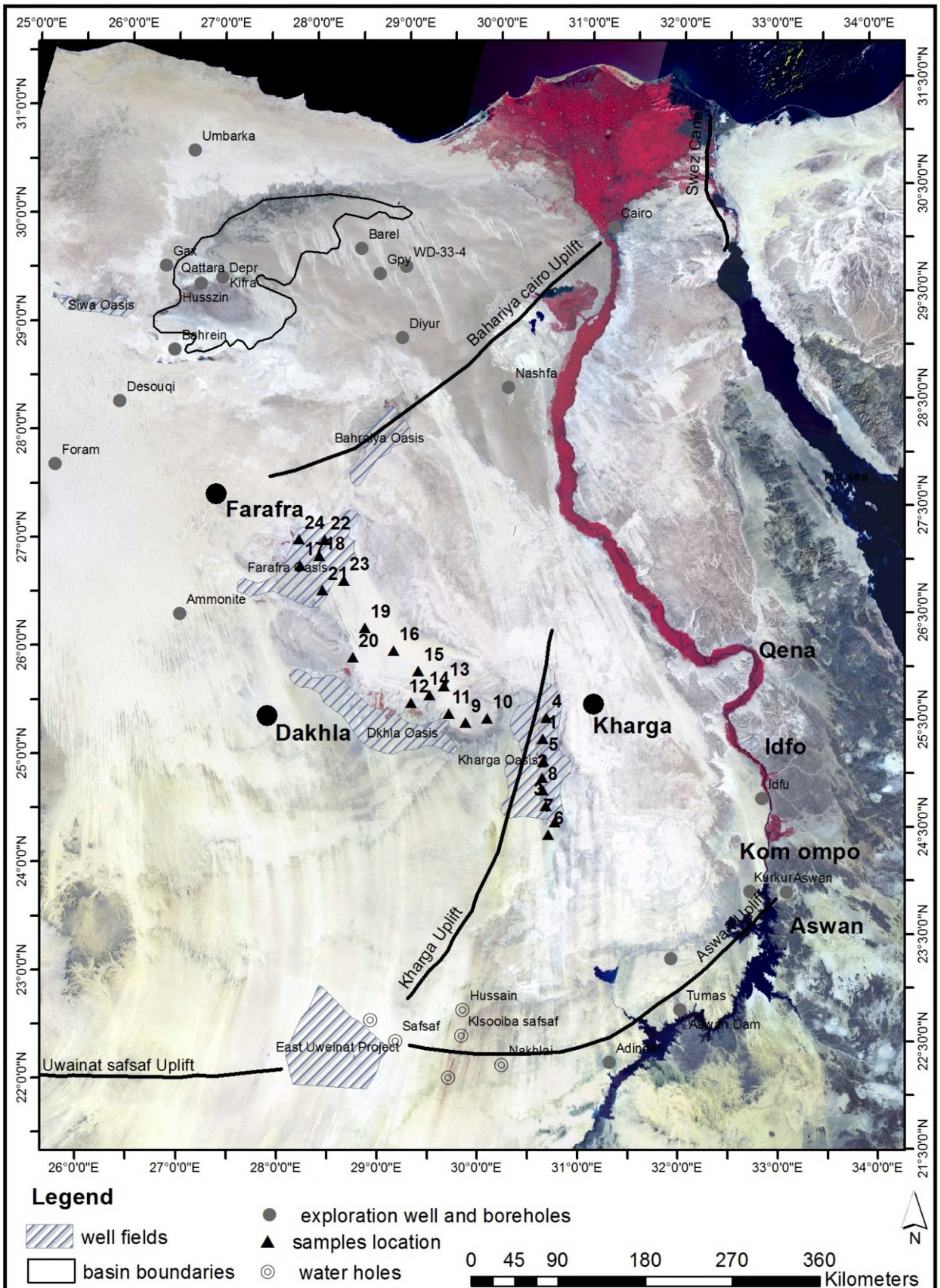

Fig (1):Nubian aquifer system and location of groundwater samples in the studied area.

Water analyses:

The collected water samples were analyzed for the major constituents using the standard methods, as follow:

Salt concentration

Total soluble salts were determined in the water samples by measuring the electrical conductivity (ECe) according to USDA (2004).

Groundwater pH: was measured in the groundwater using Bockman pH meter (Jackson, (1973).

Soluble Cations:

Calcium and magnesium were determined by the versenate method using ammonium perpiorate as an indicator for calcium and magnesium, and meruaxid indicator for calcium, according to Jackson (1973). Sodium and potassium were determined using Perkin flamphotometer according to Jackson (1973).

Soluble anions:

Soluble carbonate and bicarbonates were measured by HCL titration using phenolphthalein and methyl orange indicators (Jackson 1973). Chlorides were titrated using Mohr,s method , Jackson (1973). Sulphates were determined by the turbidimetry method using barium chloride according to USDA (2004).

*****Sodium adsorption ratio (SAR) was calculated using the following equation

$$SAR = \frac{\mathrm{Na}}{\sqrt{\mathrm{Ca} + \mathrm{Mg}/2}}$$

*****Residual sodium carbonate (RSC): was calculated using the following equation

RSC= ($CO_3^{=}$ meq/l + $HCO3^{-}$ meq/l) – (Ca^{++} meq/l) + Mg^{++} (meq/l)).

RESULTS AND DISCUSSION

Hydrogeochemistry

The following discussion groundwater quality in the study area using a total (TDS), hydrogen ion concentration (pH), hydrochemical coefficients, hypothetical salts combinations and spatial variations in groundwater chemistry.

Electrical conductivity (ECe):

This character depends 0n the concentration of the dissolved ionized salts. It can be used as a tool to measuring the salinity of the water (table 1). The electric conductivity of groundwater in El- Kharga, El- Dakhla and El- Farafra Oases ranges form 0.41 to 1.20, 0.187 to 1.250 and 0.263 to 0.36 dSm-1, respectively.

The highest (EC) value is detected in the sample No. 10 (Bir Tenieda), while the lowest value is found in sample No. 12 (Bir Mut).The conductivity is low in El Dakhla and El- Farafra Oases and the regional salinity distribution shows increasing salinities towards El- Kharga Oasis. The salinity content in the studied area is mainly governed by location of each well, the subsurface structure setting of water beasing layers and the lithological variations.

Total dissolved salts (T.D.S)

The TDS contents of groundwater samples (Table 1), ranged from 263 to 768, 112 to 750 and 146 to 230 ppm in El-Kharga, El- Dakhla and El- Farafra Oases, respectively. The highest average of TDS was obtained in water of El – Kharga Oasis but the lowest value of TDS was found in El – Farafra Oasis

Hydrogen ion activity (pH):

pH value of water is related to is quality and affects to a great extent, its suitability for different uses. The water pH is controlled by the amount of dissolved carbon dioxide (CO2), carbonate ($CO3^{-2}$) and bicarbonate ($HCO3^{-}$), (Domenico & Schwartz, 1990).

The values of (pH) in the studied groundwater ranged 6.9 to 8.7, 6.1 to 8.0 and 7.2 to 7.9 in El- Kharga, El- Dakhla and El- Farafra Oases, respectively. The variations of pH value are mostly due the chemical composition of the aquifer rocks.

Therefore, the origin of this water may be derived from Sandstone, shale and limestone and located in slight alkali class.

Table 1

Table 1 -2

Table 1 -3

Sodium adsorption ratio (SAR):

Sodium Adsorption ratio (SAR) measure the relative concentration of sodium to calcium and magnesium. High Sodium ions in water affect the permeability of soil and causes infiltration problems. Sodium replaces calcium and magnesium adsorbed on the soil clays minerals and causes dispersion of soil particles. Therefore, The soil when dry becomes hard and compact with low permeability.

The College of Agricultural Science (2002), Classified the irrigation water based on SAR values. Data in table (1) reveal that, all the studied groundwater sample during of this study classified as S1 group with SAR values < 10 and are characterized by excellent water suitable for irrigation, except for the groundwater sample of Ein - Grmish (sample No. 7) which could be used safely for irrigation, but under certain precautions with continuous leaching and selection of tolerant crops.

Residual Sodium Carbonate (RSC)

Bicarbonate and carbonate ions combined with calcium or magnesium will precipitate as calcium carbonate ($CaCO_3$) or magnesium carbonate ($MgCO_3$) when the soil solution concentrates in drying conditions. The concentration of Ca^{2+} and Mg^{2+} decreases relative to Na^+ and the SAR index will be bigger, causing an alkalizing effect and increasing the pH, (USDA, 2004).

The RSC is classification into three classes as follows:

1- The first class contains RSC < 1.25 meq/l and is considered as safe.
2- The second class has RSC that ranges between 1.25 and 2.5 meq/l and is considered as marginal, and
3- The third class has RSC> 2.5 meq/l and is considered as not suitable

Table (1) indicates that the calculated RSC values for all water wells and Eins Samples of the groundwater has < 1.25 meq/l RSC (class1), which is good quality and suitable for using in irrigation for all types of soils.

Major Cations:

The concentration of the determined cations, Na^+, K^+, Ca^{2+} and Mg^{2+} are shown in table (1). Sodium ion ranges between 5 ppm in Ein- Rahma (sample No. 21) to 107.13 ppm in Ein Ramah (sample No. 8). The potassium values ranged from 0.22 ppm in Asmant village (sample No. 11) to 28 ppm in Ein Grmish (sample No. 7).

The Calcium contents ranged between 8.01 ppm in Asmant village and Ein El-Khair (samples No. 11 and 16) and 77.76 ppm in Bagdad village (sample No.2). The magnesium ion ranged from 4.26 ppm in Ein El- Qaser (sample No. 6) to 30.65 ppm in Teneida village (sample No. 10). The soluble cation in the studied groundwater sample follow four orders.The frest order Ca^{2+}> Na^+>Mg^{2+}> K^+ (samples Nos. 1,2,4,5,6,9,14,and 17). The scend order Na^+> Ca^{2+}> Mg^{2+}> K^+ (samples Nos. 3,7,8,10 16 and 24). The third order Mg^{2+}> K^+ > Ca^{2+}> Na^+> (samples Nos. 11,12,and 15). The fourth order Ca^{2+}> Mg^{2+}> Na^+>K^+ (samples Nos. 13, 18, 19, 20, 21, 22, and 23). The increasing of calcium content is related to the type of water – bearing strata in which calcite, dolomite, gypsum and anhydrite are responsible for enriching the groundwater with calcium ions. The concentration of calcium also increases in El- Kharga and El- Farafra Oases due to the dissolution of Miocene limestone forming the aquifer (El- Abd, 2005).

Major Anion:

The concentration of the determined anions CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-} are shown in table (1). From the table chloride ion ranged between 5 ppm in East El Farafra well (sample No. 18) to 284 ppm in Teneida (sample No. 10). Bicarbonates range between 24.41 ppm in Ein Ramah (sample No. 8) to 170.8 ppm in Ein El-Qaser (sample No. 6) Sulphate ions varied from 9.61 ppm in Paris village (sample No. 3) and 181 ppm in Teneida village (sample No. 10). The anionic composition of the studied groundwater samples follow the order

HCO_3^- > Cl^- > $SO4^{2-,}$ excsept for the groundwater samples Nos. 2, 4, 7, 10, 17 and 24 where the anions follow the order Cl^- > HCO_3^- > $SO4^{2-.}$ In samples Nos, 13, 14, and 15 $SO4^{2-}$ ions exceed Cl^- and /or HCO_3^- , while in samples Nos. 18 and 22 the anions follow the order HCO_3^- > $SO4^{2-.}$ > Cl^-. The relatively high HCO_3^- content in the studied groundwater due to dissolution of carbonate rocks, while the sulfate content is also increased locally in El- Qasr el- Balad well (sample No. 13) and Teneida (sample No. 10) due to the extending of Miocene sediments containing gypseous limestone.

The concentration of the major cations and anions are lower than the maximum standard limits, according to the World Health Organization (WHO 1984).

Trace elements:

Table (1) reveals that, the results of trace elements (Fe and Mn) indicate that Fe ion in the studied groundwater samples varied from 1.35 ppm in Ein Makafy (sample No. 23) and 10.2 ppm in Teneida (sample No. 10), while Mn ion ranged from 0.02 in Mut vallage (sample No. 12) to 4.3 ppm in Ein el Qaser (sample No. 6).

The relatively high content of iron and manganese is related to the geological nature of the study area which enriched by these elements in their sedimentary secession (CONOCO.1987).

Hydrochemical coefficients

Expression of the ionic relationship in terms of mathematical cations is quite helpful in establishing chemical similarity among water extracted from a single aquifer. Ion ratios are also useful in detecting groundwater pollution or mixing with other water resources (Hem 1985). The chosen ion ratios, which are found to be important in the present study (table 3), are as follows,

A. (Sodium + Potasium) / Chloride ratio (r Na^+ + rK^+)/Cl^-

Table (2) shows that, values of (rNa^{2+} + rK^+)/ Cl^- for most groundwater samples (62.5%) are less than unity in the study groundwater samples in El- Kharga and El- Farafra oases, while the other water samples El- Dakhla Ein El- Qaser and Ramah have the ratios of (r Na^+ + r K^+)/ Cl^- more than unity (37.5%). This indicates that sodium ions have decrease relative to chloride ions. The decrease in the concentration of Na+ ions in these water samples reflects that groundwater in El-Kharga and El- Farafra is effected by old marine sediments. This is due to the partial flushing of marine deposits or old sea water through movement of rain water that horizontally or vertically infiltrated and settled in siliceous aquifer materials in the past time

B. Sulfate / Chloride ratio (r $SO4^{2-}$/r Cl^-):-

Most groundwater sample (79.2%) are characterized by the ratio of (r $SO4^{-2}$/ r Cl^-) less than unity and more than of sea water (0.1) (Hem, 1985), while some groundwater of Ein- Ramah, El- Qasr, El-Mawhob, Ein-Zamzam and Ein – El-Siro (20.8%) have the rate (r SO4/ r Cl) more than unity, This indicates that solution of alfate such as. Gypsum, local terrestrial source of suepsomite ($MgSO_4^-$ 7H2O), glauberite (Na2SO4. 10 H2O) and anhydrite as well as other more rare sulfate salts.

C: Chloride / bicarbonate and carbonate r Cl^-/r (HCO_3^- + $CO_3^=$)

The study of this parameter is useful to separate a trend of salinization and areas which effected by old marine sediment or sea water intrusion, Tood (1980) categorized groundwater according to this ratio as follows:

Normal good groundwater (less than 1), slightly contaminated water (more than 1 and less than 2), moderately contaminated water (2-6), seriously contaminated water (more than 15) and highly contaminated water (more than 15). Data in table (2) reveal that most groundwater samples (50% of total samples) have a ratio of more than 1 and less than 2, therefore they are considered slightly contaminated water. 29.2% of total samples have a ratio of less than 1, and considered normal good groundwater samples, while the samples of Ein- Khalfa, Ein- El- Farafra and East El Farafra have the ratio more than 2 and less than 6 indicating that these water samples are considered moderately contaminated water. Water sample of Teneida has the rate 12.5% indicating that these water samples is seriously contaminated water. This means that the groundwater have possibly a pure meteoric origin, affected by continental from normal to seriously contaminated as a result of the impact of old marine sediments.

Table (2): Hydrochemical coefficients of the groundwater samples in the studied area.

Samples Nos.	**Location**	$\frac{rNa + rK}{rCl}$	$\frac{rSO4}{rCl}$	$\frac{rCl -}{r(HCO3 + CO3)}$	$\frac{rSO4}{r\ anions} - \frac{rNa}{r\ cations}$ **×100**
El- Kharga					
1	Palastine Village	0.64	0.09	1.30	-23.9
2	Bagdad Village	0.54	0.12	1.74	-19.6
3	Paris village	0.96	0.05	1.67	-51.76
4	Kuit village	0.49	0.06	1.74	-20.7
5	Jeda village	0.81	0.53	1.50	-8.20
6	Ein El- Qaser	1.01	0.37	1.43	-28.0
7	Ein Grmsh	0.75	0.19	1.93	-20.9
8	Ein Ramah	2.01	1.69	0.76	-4.70
El- Dakhla					
9	Balat	1.25	0.50	0.90	-6.90
10	Teneida	0.92	0.47	11.79	-24.8
11	Asmant	1.24	0.58	0.84	6.6
12	Mut	1.24	0.56	0.84	6.00
13	El-Qasr El- Balad well	1.05	1.41	1.26	17.9
14	El-Mawhob well	1.07	1.33	1.96	15.6
15	Ein Zamzam	1.29	1.04	1.22	6.5
16	El- Khair	1.73	0.79	1.16	-20.9
El- Farafra					
17	El-Farafra well	0.63	0.34	2.15	-10.7
18	East El- Farafra well	0.43	0.47	2.15	-4.1
19	Abo - Monkar well	0.39	0.36	1.72	-7.5
20	El Wadi well	0.48	0.40	0.81	-2.7
21	Ein El- Rahma	0.23	0.63	1.01	-15.9
22	Ein El Siro	0.68	1.05	0.81	-13.1

23	Ein Makafy	0.99	0.72	0.69	-0.4
24	Ein Khalfa	0.93	0.53	2.53	-35.9

Table (3): Hydrochemical composition of the studied different groundwater in meq/l.

Samples Nos.	**Location**	(K+Na-Cl)/SO_4	**Cl+SO_4**	**(K^++Na)**	**(K+Na+Ca+Mg)**	**CL-(Na+K)/Mg**
			El- Kharga			
1	Palastine Village	-4.04	3.27	1.91	5.57	0.73
2	Bagdad Village	-3.96	4.47	2.14	6.77	1.15
3	Paris village	-0.80	4.20	3.84	6.62	-0.57
4	Kuit village	-7.63	4.27	1.94	6.57	2.42
5	Jeda village	-0.36	4.60	2.43	6.60	1.07
6	Ein El- Qaser	0.01	5.48	4.02	8.28	-6.58
7	Ein Grmsh	-1.31	3.94	2.46	5.41	1.57
8	Ein Ramah	0.66	6.6	5.23	9.56	-2.11
			El- Dakhla			
9	Balat	0.5	1.14	0.95	1.99	-1.07
10	Teneida	-0.18	11.79	7.34	12.66	5.11
11	Asmant	0.42	1.04	0.82	1.82	-0.71
12	Mut	0.43	1.03	0.82	1.82	-0.92
13	El-Qasr El- Balad well	0.04	2.24	0.98	2.98	-0.09
14	El-Mawhob well	0.05	2.42	1.11	2.95	-0.28
15	Ein Zamzam	0.28	1.84	1.16	2.60	-0.42
16	El- Khair	0.92	1.92	1.85	2.85	-2.01
			El- Farafra			
17	El-Farafra well	-1.22	2.46	1.06	3.26	0.06
18	East El- Farafra well	-1.22	2.28	0.66	3.21	0.98
19	Abo - Monkar well	-2.71	2.07	0.66	3.25	1.02
20	El Wadi well	-1.32	1.10	0.38	2.10	0.18
21	Ein El- Rahma	-1.21	1.62	0.23	2.62	0.76
22	Ein El Siro	-0.30	1.62	0.54	2.78	0.24
23	Ein Makafy	-0.02	1.84	1.19	3.96	0.21
24	Ein Khalfa	-0.28	5.27	3.94	7.43	1.65

e) Other ratios

D' Amore *et al* (1984) has documented the use of a set of ionic ratio can be used in revealing the chemical genesis of groundwater

{r $SO4^{2-}$/r (Anionic)– r Na^+/ r(cationic)} ×100

The parameter discriminates between sulfate – enriched water circulating in evaporitic terrains and sodium – enriched water that encountered in marly, clayey sedimentary terrains.

Table (2), reveals that most of the groundwater samples (83.3%) have negative values of this ratio. This means that Na^+ ion exceeds $SO4^{2-}$, indicating the impact of old marine sediments and groundwater passage in marl and clays, while (16.7%) of the studied groundwater samples have positive values of this ratio and means that $SO4^{2-}$ exceeds Na+ indicating evaporate terrains. Studing of these ionic, the main finding is that the groundwater have a mixed origin that is possibly pure meteoric water affected, to a less extent, by traces of marine faces. The groundwater aquires its quality from leaching and dissolution of salts by passage of groundwater into the carbonates, clay, gypsum, basement rocks and evaporates in the aquifer matrix.

Hydrogenesis of the studied water point

The origin of the groundwater in the study aquifers was interpreted according to the classification of (Hem 1985) and the diagram of Suline (1946), Fig (2).

All aquifers in the study area of El-Dakhla, El- Kharga and El- Farafra Oases are characterized by parameters (K + Na – Cl) / SO_4 < 1 and Cl + SO_4 > K + Na < K + Na + Ca + Mg (Table 3). Accordingly, water are equivalent to those of zones I and Π of Sulin,s diagram (Fig. 2) These parameter indicate that the studied groundwater samples are percolated old meteoric and old marine type, which reflect the prevalence of continental meteoric freshwater conditions. which replaced the original depostional marine saline water trapped between the pores of the Nubian sandstone.These results agreement with those obtained by El-Nahry et al (2010). In conclusion, Sulin,s diagram suggest that the groundwater samples of the study area have mixed types of mineralization, i.e the flushing of marine deposits or old sea water through movement and rain that vertically infiltrated and settled in the siliceous aquifer materials in the past time

Hypothetical Salts combinations

Hypothetical ions of the strong acids (Cl^- and SO_4^{2-}) from chemical combination with alkali (Na^+ and K^+) and the rest of acid radical combine with alkaline earths (Ca^{2+} and Mg^{2+}). If the cations of alkali and alkaline earths are surplus in groundwater they well combine with anions of the weak acids (CO_3^{2-} and HCO_3^-).

The hydrochemical characteristics of the studied groundwater samples, data in table (4) reveal that the hydrochemical composition of the studied samples are expressed from hydrochemical formula in which the anionic and cationic concentration are presented in equivalent percentages and arranged in decreasing order of their decreasing concentrations. From the table, the data show that among the cationic concentration,calcium and / or sodium are the most dominated followed by magnesium ions and potassium. The chlorides and / or hydrocarbonates concentration are the most dominated anions, followed by sulfate.

Also, it is clear from table (3), that the prevailing salt combination (hydrochemical) of the studied water in El-kharga oasis have the following assemblages

1- KCl, NaCl, $MgCl_2$, $CaCl_2$, $CaSO_4$, $Ca(HCO_3)_2$ (37.5% of the total samples).
2- KCl, NaCl, $MgCl_2$, $MgSO_4$, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$ (37.5 of the tptal samples).

3- KCl, NaCl, Na_2SO_4, $MgSO_4$, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$ (25% of total samples)

In El- Dakhla Oasis, the groundwater samples have the following assemblages

1- KCl, NaCl, Na_2So_4, $MgSO_4$, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$ (62.5% of the total samples.

2- KCl, NaCl, $NaSO_4$, $MgSO_4$, $CaSO_4$, $Ca(HCO_3)_2$ (37.5% of the total samples)

Regarding to the groundwater samples of El- Farafra Oasis, the samples have the following order

1- NaCl, $MgCl_2$, $MgSO_4$, $CaSO_4$, $Ca(HCO_3)_2$ (62.5% of total samples).

2- NaCl, MgCl2, MgSO4, Ca(HCO3)2 (37.5% of total samples).

From the hypothetical salts combination, the studied groundwater samples indicate that the factors affecting groundwater quality are leaching and dissolution, and also the presence of, KCl, NaCl, $CaCl_2$ and $MgCl_2$, saltoalong these groundwater reflects the effect of an old marine sediments in the study area. The assemblages of salts combination characterize groundwater of the studied water samples regardless of their salinities Generally, these salts assemblage reflect of leaching and dissolution of terrestrial salts. The different hydrochemical facies corresponds to the variations in lithology (geological formations), groundwater recharge rates, temperature gradients and residence time of groundwater in the subsurface semi- closed structural troughs.

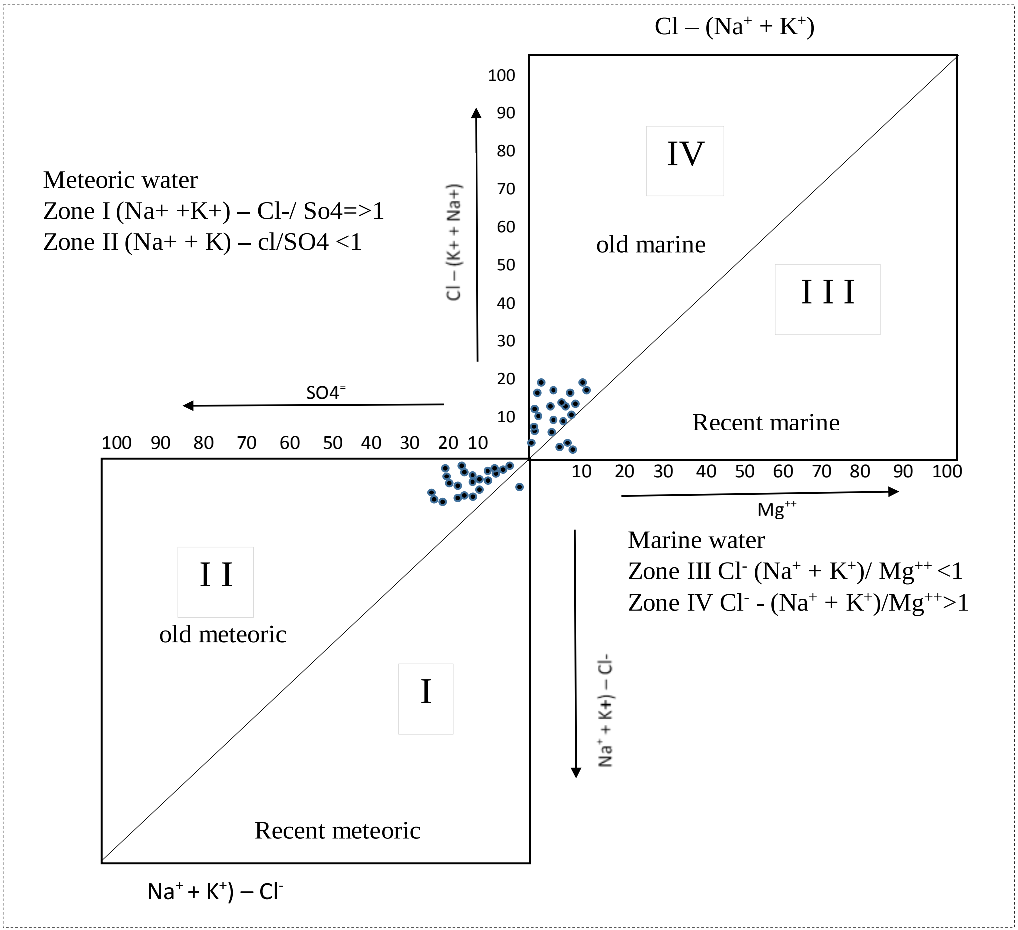

Fig (2): Sulin,s graph for representing hydrochemical composition deferent of the different water in meq/l) or (%).

Table 4

Groundwater evaluation for general uses

Generally, the water used for most domestic and industrial uses should contain less than 1000 ppm total dissolved salts (TDS), and that used for most agricultural uses should contain less than 3000 ppm. TDS.

The final classification of water in relation to potential use, however, should be based on concentrations of ions rather than T.D.S The evaluation of groundwater in the area under study is based on the standards established by the WHO (1984)

*Evaluation of ground water for drinking and domestic purposes

In general, water for drinking and domestic uses should be colorless, odorless, clean and free from excessive dissolved solids as well as harmful organisms. Generally, for water of good quality (potable), the total dissolved solids (TDS) should not exceed 500 mg/l (WHO), (1984). Applying the International Standards recommended by World Health Organization (1984), Table (5) on the collected ground water samples with respect to their suitability for drinking and domestic purposes, the following results can be deduced

Generally, the ground water of the studied area is suitable for both drinking and domestic purposes. All values of the pH, SO_4^{-2} , Cl^-, Mg^{+2}, and Ca^{+2} of the groundwater samples are within the acceptable limit. With respect to salinity content, all groundwater samples salinity less than 500 ppm, and thus fall within the acceptable limits, except for the groundwater of Jada well sample No. (5), Ein el Qaser sample No. (6) and Teneida well sample No. (10) which have salinities more than 500 ppm. However, the trace elements contents (Fe and Mn) are mostly above the critical limits for drinking according to WHO (1984), except for Bir Mut, Bir El- Farafra, Ein- Rahma and Ein-Makafy for Mn. Therefor, the groundwater of the studied area is not suitable for drinking usage. According the Fe and Mn concentration.

*Evaluation of groundwater for livestock and poultry.

Most animals are able to use water that is considerably higher in dissolved solids than that is considered satisfactory for humans. But water that used by stock is also subjected to quality limitation, Table (5). Where excessive salinity or high levels of specific ions in livestock drinking water can causes animal health problems.

Composing the information given by National Academy of Science, (NAS) 1972 (Table - 6) with the results of groundwater samples (Table 1), the results indicate that all the studied groundwater samples are excellent water for all classes of livestock and poultry (TDS < 1000 ppm) comprise 100% of the groundwater samples.

Table (5): International standards for drinking water (WHO 1984)

Water uses elements	Acceptable (ppm)	Permissible (ppm)
pH	7-8.5	6.5-9.2
TDS	500	1500
Cl-	200	600
SO42-	200	400
Mg+2	50	150

Ca^{+2}	75	200
Fe	0.3	1.0
Mn	0.1	0.5

*Evaluation of groundwater for agricultural uses

Irrigation water quality has direct effects on plants, crop yield, and soil of any cultivated area. It depended on the content of elements that are harmful to plants and soils. The quality requirements of irrigation water vary between crops, types and drain ability of the soils and climate.

Table (7) shows that the classification of the groundwater samples of the studied area according to their ECe and SAR values (Richard, 1954). The results of studied groundwater samples reveal that 12.5%, 70.8%, 4.2% and 12.5% representing C1-S1, C2-S1, C2-S2 and C3-S1, respectively. The data show the majority of groundwater sample, moderately suitable and marginally suitable for irrigation crops.

Table (6): Guide to the use of saline water for livestock and poultry (National Academy of Science, 1972).

TDS in mg/1	Characters
Less than 1000 mg/1	Relatively low level of salinity. Excellent for all classes of livestock and poultry.
1000 to 2999 mg/1	Very satisfactory for all classes of livestock and poultry. Many causes temporary and mild diarrhea in livestock not accustomed to them or water dropping in poultry.
3000 to 4999 mg/1	Satisfactory for livestock, but may causes temporary diarrhea or refused at first by the animal not accustomed, poor water for poultry, often causing water faces, increased mortality and decreased growth, specially in turkeys.
5000 to 6999 mg/1	Can be used with reasonable safety for dairy and beef cattle, for sheep, swine, and horses. Avoid use for pregnant or lactating animals. Not acceptable for poultry.
7000 to 10000 mg/1	Unfit for poultry and probably for swine, considerable risk in using for pregnant or lactating cows, horses, or sheep, or for the young of these species. In generally, use should be avoided although older ruminants, horses, poultry, and swine may subsist on them under certain conditions.
Over 10000	Risk with this highly saline water is so great that they cannot be

mg/1	recommended for use under any conditions.

Table (7): ECe and SAR values of the studied well and Ein groundwater samples and their water suitability for irrigation

Sample No.	Location	ECe ds/m^{-1}	SAR Order	Class	Suitability for Irrigation
El- Khaga					
1	**Palastine**	0.55	1.18	C2-S1	Moderately suitable
2	**Bajada**	0.56	1.20	C2-S1	Moderately suitable
3	**Paris**	0.73	3.0	C2-S1	Moderately suitable
4	**Kiut**	0.63	1.1	C2-S1	Moderately suitable
5	**Jeda**	1.20	1.5	C3-S1	Marginally suitable
6	**Ein El- Kaser**	0.96	2.6	C3-S1	Marginally suitable
7	**Palastine**	0.56	11.54	C2-S2	Moderately suitable
8	**Bajada**	0.41	4.48	C2-S1	Moderately suitable
El-Dakhla					
9	**Balat**	0.195	0.72	C1-S1	Highly suitable
10	**Teneida**	1.250	4.27	C3-S1	Marginally suitable
11	**Asmant**	0.208	0.65	C1-S1	Highly suitable
12	**Mut**	0.187	0.37	C1-S1	Highly suitable
13	**El-Qasr El-Balad**	0.300	0.78	C2-S1	Moderately suitable
14	**El- Mouhob**	0.298	0.95	C2-S1	Moderately suitable
15	**Ein Zamzam**	0.290	0.92	C2-S1	Moderately suitable
16	**Ein el Khair**	0.287	2.03	C2-S1	Moderately suitable
El- Farafra					
17	**El- Farafra**	0.263	0.95	C2-S1	Moderately suitable
18	**East el Farafra**	0.305	0.58	C2-S1	Moderately suitable
19	**Abu Monkar**	0.288	0.57	C2-S1	Moderately suitable
20	**El Wadi**	0.360	0.40	C2-S1	Moderately suitable
21	**Ein Rahma**	0.280	0.20	C2-S1	Moderately suitable

22	**Ein El Siro**	0.350	0.49	C2-S1	Moderately suitable
23	**Ein Makafa**	0.33	0.61	C2-S1	Moderately suitable
24	**Ein Makafa**	0.32	2.86	C2-S1	Moderately suitable

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تقييم جودة المياة الجوفية ومدي صلاحياتها للإستخدامات المختلفة في الواحات الخارجة والداخلة والفرافره – الصحراء الغربيه – مصر

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الملخص العربى

المياة الجوفية هي المصدر الرئيسي والأساسي للإستخدامات المختلفة في الصناعه الزراعة والحياه اليومية في الواحات الخارجه والداخلة والفرافرة في الصحراء الغربية، مصر وهذه المياه تختلف في جودتها. والخواص الكيميائية للأيونات الرئيسية لهذه المياه والتي تشتمل علي كاتيونات الصوديوم والبوتاسيوم والماغنسيوم والكالسيوم وأنيونات الكلوريد والكبريتات والبيكربونات والكربونات بالأضافه الي العناصر الصغري ومنها الحديد والمنجنيز من العوامل المحدده لاستخدام المياه الجوفيه في الصحراء الغربية وبالأخص في الواحات والتي تعتمد إعتماداً رئيسياً علي المياه الجوفية. وهذا البحث يهدف الي دراسة

1- الخواص الكيميائية للمياه الجوفيه

2- أصل المياة الجوفية في الواحات تحت الدراسة

3- تقييم المياة الجوفية للإستخدامات المختلفة في هذه الواحات

وقد أختير 24 عينة مياه جوفيه تمثل مياه الأبار والعيون المنتشره في كل من الواحات الخارجه والداخله والفرافره واجري عليها التحليلات الكيميائيه المختلفه وتشير الدراسة الي ما يلي.

التوصيل الكهربي (ECe) تختلف ما بين 0.187 (بئر موط) الي 1.25 ملليموز/سم (بئر تنيده) وتزداد ملوحة المياه الجوفيه في واحة الخارجه، أما المجموع الكلي للأملاح الصلبه الذائبة (TDS) تتراوح ما بين 112جزء في المليون في بئر موط الي 768 جزء في المليون (بئر تنيده). وتشير نتائج الأس الهيدروجيني (pH) الي أن حموضة المياة تتراوح ما بين حمضي خفيف الي قلوي شديد حيث تراوحت قيم pH ما بين 6.1 الي 8.7 لذا فإن هذه المياه تكون مساق من الحجر الرملي النوبي والطين والحجر الجيري. النسبه الأدمصاصيه للصوديوم (SAR) وكربونات الصوديوم المتبقيه (RSC) تبين أن هذه المياه جيده وصالحه للاستخدامات الزراعيه. وتميزت الكاتيونات الذائبه بسيادة كاتيون الكالسيوم فالصوديوم والماغنسيوم وأخيراً البوتاسيوم أما الأنيونات الذائبة فقد تميزت بسيادة انيون البيكربونات يلية الكلوريد فالكبريتات. وتركيز هذه الكاتيونات في هذه المياه الجوفيه أقل من الحد المسموح به للأستخدام فيما عدا الحديد والمنجنيز فقد كان أعلي من الحد المسموح به للأستخدام حسب مواصفات منظمة الصحه العالمية (WHO 1984) ولتحديد أصل هذه المياة الجوفيه تم تطبيق التصنيف الجيوكيميائي للمياة الجوفيه علي أساس الانيونات والكاتيونات وحساب النسب الأيونيه التاليه:

$(rNa + rK/Cl^-)$, $\frac{rSO_4^{=}}{rCl^-}$, $\frac{rCl^-}{r(HCO_3^- + CO_3^{=})}$ & $\left(\frac{rSO_4^{=}}{r\,anions} - \frac{nr\,Na^-}{r\,cations}\right) \times 100$

وتوضح نتائج هذه النسب المختلفه الي أن أصل المياة الجوفية في مناطق الدراسة يرجع الي خليط من نوعيات مختلفة وعلي وجه التحديد الي مياه جوية (مطرية) متأثره بأثار من ملوحة مياة البحر القديم أو الرواسب البحرية المترسبه في الصخور الحامله للمياه .

وقد أمكن تقييم نوعية المياه في الواحات الخارجه والداخله والفرافره للإستخدامات المختلفه وتبين أن هذه النوعيه من المياه غير صالحه للإستخدام الأدمي (للشرب) لإرتفاع تركيز الحديد والمنجنيز بها عن الحد المسموح به طبقاً لطرق القياس العالمية ولكنها صالحه لشرب الماشيه والدواجن كما أنها صالحه للزراعه والري تحت ظروف التربة العاديه.

Table (1): Chemical analyses water sample of the studied areas.

Sample No.	Location	unit	Cations				Total epm	Anions				Total epm	Fe (ppm)	Mn (ppm)	PH	TDS (ppm)	ECe dSm^{-1}	SAR	RSC
			$^{+}$ Na	$^{+}$ K	Ca^{++}	Mg^{++}		$^{-}$ Cl	$HCO3^{-}$	$SO4^{=}$	$CO3^{=}$								
El-Kharga																			
1	**Palastine Village**	ppm	36.8	12.12	56.51	10.21		106.38	140.32	12.96	-		2.8	0.3	8.40	352			
		e.p.m	1.60	0.31	2.82	0.84	5.57	3.00	2.30	0.27	-	5.57					0.55	1.18	-1.36
		%	28.73	5.57	50.63	15.10		53.9	41.3	4.80	-								
2	**Bagdad Village**	ppm	42.78	10.95	77.76	9.12		141.84	141.32	22.57	-		3.48	0.05	8.70	358			
		e.p.m	1.86	0.28	3.88	0.75	6.77	4.0	2.3	0.47	-	6.77					0.56	1.22	-2.33
		%	27.47	4.14	57.31	11.07		59.08	33.97	6.94	-								
3	**Paris Village**	ppm	82.8	7.22	38.88	10.21		141.84	146.4	9.61	-		6.0	0.05	8.10	467			
		e.p.m	3.60	0.24	1.94	0.84	6.62	4.0	2.4	0.20	-	6.6					0.73	3.05	-0.38
		%	54.4	3.63	29.31	12.69		60.61	36.4	3.03	-								
4	**Kuit Village**	ppm	37.49	9.33	68.14	14.36		141.84	140.32	12.96	-		3.4	0.07	8.50	403			
		e.p.m	1.63	0.31	3.40	1.23	6.57	4.0	2.3	0.27	-	6.57					0.63	1.07	-2.33
		%	24.81	4.72	51.75	18.72		60.88	35.01	4.11	-								
5	**Jeda Village**	ppm	49.22	8.73	58.32	15.31		106.38	122.02	28.82	-		6.2	0.35	8.20	768			
		e.p.m	2.14	0.29	2.91	1.26	6.60	3.0	2.0	1.60	-	6.6					1.20	1.50	-2.17
		%	32.42	4.40	44.1	19.1		45.45	30.30	24.24	-								
6	**Ein El- Kaser**	ppm	87.4	6.62	77.76	4.62		141.04	170.8	71.o8	-		3.o	4.30	8.3	614			
		e.p.m	3.80	0.22	3.88	0.38	8.28	4.0	2.8	1.48	-	8.28					0.96	2.60	-1.46
		%	45.9	2.66	46.86	4.60		48.4	33.82	17.87	-								
7	**Ein Grmsh**	ppm	40.0	28.0	31.0	17.0		117	104.5	31.0	-		5.4	0.05	7.0	361	0.56		
		e.p.m	1.74	0.72	1.55	1.4	5.41	3.30	1.71	0.64	-	5.65						1.43	-1.24
		%	32.16	13.31	28.65	25.88		58.41	30.27	11.33	-								
8	**Ein Ramah**	ppm	107.13	22.29	64.53	13.5		9.22	24.41	21.13	-		3.7	0.28	6.90	263			
		e.p.m	4.66	0.57	3.22	1.11	9.56	2.60	3.4	4.0	-	10.0					0.41	3.17	-4.97
		%	48.74	5.96	33.68	11.61		26.0	34.0	40.0	-								

Table (1): cont.

Sample No.	Location	Unit	Cations				Total epm	Anions				Total epm	Fe (ppm)	Mn (ppm)	PH	TDS (ppm)	ECe dSm^{-1}	SAR	RSC
			Na^+	K^+	Ca^{++}	Mg^{++}		Cl^-	$HCO3^-$	$So4^=$	$CO3^=$								
El-Dakhla																			
9	Balat	Ppm	12	17	10.4	6.32		27	51.24	18.4	-		3.5	0.32	7.6	117	0.195		
		e.p.m	0.52	0.43	0.52	0.52	1.99	0.76	0.84	0.38	-	1.98						0.72	-0.20
		%	26.1	21.6	26.1	26.1		38.4	43.4	19.2	-								
10	Teneida	Ppm	160	15.0	56.1	30.65		284	41.63	181	-		10..2	0.32	7.5	750	1.250		
		e.p.m	6.96	0.38	2.80	2.52	12.66	8.02	0.68	3.77	-	12.47						4.27	-4.64
		%	54.98	3.0	22.12	19.91		64.3	5.5	30.2	-								
11	Asmant	Ppm	6.0	0.22	8.01	7.20		23.3	48.04	18.4	-		3.8	0.4	7.1	125	0.208		
		e.p.m	0.26	0.56	0.40	0.60	1.82	0.66	0.79	0.38	-	1.83						0.37	-0.21
		%	14.3	30.8	21.9	32.97		36.1	43.2	20.8	-								
12	Mut	Ppm	6.0	22.0	9.61	6.32		23.3	48.04	17.8	-		4.3	0.02	8	112	0.187		
		e.p.m	0.26	0.56	0.48	0.52	1.82	0.66	0.79	0.37	-	1.82						0.37	-0.21
		%	14.3	30.8	26.4	28.6		36.3	43.4	20.3	-								
13	El-Qasr El- Balad well	ppm	18.0	8.0	20.8	11.68		33.0	44.84	63.1	-		9.0	0.17	6.1	180	0.300		
		e.p.m	0.78	0.2	1.04	0.96	2.98	0.93	0.74	1.31	-	2.98						0.78	-1.26
		%	26.2	6.7	34.9	32.2		31.2	24.8	43.9	-								
14	El-Mawhob well	ppm	21.0	8.0	20.0	10.22		36.7	32.03	66.2	-		6.4	0.17	6.4	179	0.298		
		e.p.m	0.91	0.2	1.0	0.84	2.95	1.04	0.53	1.38	-	2.95						0.95	-1.31
		%	30.8	6.8	33.9	28.5		35.3	17.97	46.8	-								
15	Ein Zamzam	Ppm	18.0	15.0	11.2	10.7		32.1	44.84	45.3	-		3.94	0.25	6.5	156	0.260		
		e.p.m	0.78	0.38	0.56	0.88	2.60	0.90	0.74	0.94	-	2.58						0.92	-0.7
		%	30	14.6	21.5	33.8		34.9	28.7	36.4	-								
16	El- Khair	Ppm	33.0	16.0	8.01	7.30		37.9	56.04	41.0	-		2.3	0.16	7.7	172	0.287		
		e.p.m	1.44	0.41	0.40	0.60	2.85	1.07	0.92	0.85	-	2.84						2.03	-0.08
		%	50.5	14.4	14.04	21.1		37.7	32.4	29.93	-								

Table (1): cont.

Sample No.	Location	Unit	Cations				Total epm	Anions				Total Epm	Fe (ppm)	Mn (ppm)	PH	TDS (ppm)	ECe dSm-1	SAR	RSC
			Na+	K+	Ca++	Mg++		Cl-	HCO3-	So4=	CO3=								
El- Farafra Oases																			
17	El-Farafra well	Ppm	25.0	2.50	32.0	7.50		65.0	52.0	30.0	-		5.7	0.01	7.2	223.9	0.355		
		e.p.m	1.00	0.06	1.60	0.60	3.26	1.83	0.83	0.63	-	3.29						0.95	-1.37
		%	30.7	1.80	49.1	18.4		55.6	25.2	19.1	-								
18	East El-Farafra well	Ppm	16.0	0.50	28.0	14.0		5.0	44.0	35.0	-		3.2	0.8	7.5	170	0.263		
		e.p.m	0.65	0.01	1.40	1.15	3.21	1.55	0.72	0.73	-	3.0						0.58	-1.83
		%	20.25	0.31	43.61	35.83		51.7	24.0	24.3	-								
19	Abul-Monkar well	ppm	15.0	0.50	32.0	12.0		60.0	60.0	18.0	-		4.4	0.2	7.3	195	0.305		
		e.p.m	0.65	0.01	1.60	0.99	3.25	1.69	0.98	0.38	-	3.05						0.57	-1.61
		%	20.0	0.31	49.2	30.46		55.4	32.13	12.5	-								
20	El Wadi well	ppm	8.50	0.50	22.0	7.50		28.0	60.0	15.0	-		4.9	0.2	7.5	146	0.288		
		e.p.m	0.37	0.01	1.10	0.62	2.10	0.79	0.98	0.31	-	2.08						0.40	-0.74
		%	17.6	0.48	52.4	29.5		37.98	47.1	14.9	-								
21	Ein El-Rahma	ppm	5.0	0.5	28.0	12.0		35.0	60.0	30.0	-		3.0	0.1	7.5	230	0.36		
		e.p.m	0.22	0.01	1.4	0.99	2.62	0.99	0.98	0.63	-	2.6						0.20	-1.41
		%	8.4	0.38	53.4	37.8		38.1	37.7	24.2	-								
22	Ein-El Siro	ppm	12.0	0.80	25.0	12.0		28.0	60.0	40.0	-		4.4	0.2	7.2	178	0.28		
		e.p.m	0.52	0.02	1.25	0.99	2.78	0.79	0.98	0.83	-	2.60						0.49	-1.26
		%	18.7	0.72	44.96	35.6		30.4	37.69	31.92	-								
23	Ein-Makafy	ppm	16.6	18.4	31.5	14.6		42.6	106.8	30.74	-		1.35	0.1	7.2	227	0.35		
		e.p.m	0.72	0.47	1.57	1.20	3.96	1.20	1.75	0.64	-	3.59						0.61	-1.02
		%	18.2	11.9	39.6	30.3		33.4	48.7	17.8	-								
24	Ein-Khalfa	ppm	86.9	6.26	39.3	18.6		150	102	43.9	-		6.0	0.3	7.9	213	0.33		
		e.p.m	3.78	0.16	1.96	1.53	7.43	4.23	1.67	1.04	-	6.94						2.86	-1.82
		%	50.9	2.15	26.4	20.6		60.95	24.1	14.99	-					198.3	0.32		

Table (4): Hypothetical salts of groundwater in the study water samples.

Sample No.	Location	KCl (e%)	NaCl (e%)	$MgCl_2$ (e%)	$CaCl_2$ (e%)	K2SO4 (e%)	Na_2SO_4 (e%)	$MgSO_4$ (e%)	$CaSO_4$ (e%)	$KHCO_3$ (e%)	$Mg(HCO_3)_2$ (e%)	$Ca(HCO_3)_2$ (e%)	Sum (e%)
El-Kharga													
1	**Palastine**	5.57	28.73	15.10	4.5	--	--	--	4.80	--	--	45.83	99.43
2	**Bajada**	4.14	27.5	11.07	16.37	--	--	--	6.94	--	--	34.00	100.02
3	**Paris**	3.63	54.4	2.58	--	--	--	3.03	--	--	9.84	29.31	102.79
4	**Kiut**	4.72	24.81	18.72	12.64	--	--	--	4.11	--	--	35.00	100
5	**Jeda**	4.4	32.42	8.63	--	--	--	10.47	3.77	--	--	40.33	100.02
6	**Ein El- Kaser**	2.66	45.64	--	--	--	0.26	4.6	13.01	--	--	33.87	100.04
7	**Ein Grmsh**	13.31	32.16	12.94	--	--	--	11.33	--	--	1.61	28.65	100
8	**Ein Ramah**	5.96	20.04	--	--	--	28.70	11.30	--	--	0.31	33.69	100
El- Dakhla													
9	**Balat**	21.6	16.8	--	--	--	9.3	9.9	--	--	16.2	26.2	100
10	**Teneida**	3.0	54.98	6.32	----	--	--	13.59	16.61	--	--	4.51	99.01
11	**Asmant**	30.8	5.3	--	--	--	9.0	11.8	--	--	21.17	22.03	100.1
12	**Mut**	30.8	5.5	--	--	--	8.8	11.5	--	--	17.1	26.3	100
13	**El-Qasr El-Balad**	6.7	24.5	--	--	--	1.7	32.0	10.0	--	--	24.9	100
14	**El- Mouhob**	6.8	28.5	----	--	--	2.3	28.5	16.0	--	--	17.9	100
15	**Ein Zamzam**	14.6	20.5	--	--	--	9.5	26.9	--	--	6.9	21.8	100
16	**Ein el Khair**	14.4	23.3	--	--	--	26.7	3.23	--	--	17.87	14.53	100.03
El- Farafra													
17	**El- Farafra**	1.8	30.7	18.4	--	--	--	--	19.1	----	--	25.3	100
18	**East el Farafra**	0.3	20.2	31.2	--	--	--	4.6	19.7	--	--	23.9	99.9
19	**Abu Monkar**	0.31	20.0	30.5	4.9	--	--	--	12.5	--	--	31.8	100.01
20	**El Wadi**	0.48	17.6	19.9	--	--	--	9.6	5.3	--	--	47.1	99.98
21	**Ein Rahma**	0.38	8.4	29.3	--	--	--	8.5	15.7	--	--	37.7	99.98
22	**Ein El Siro**	0.72	18.7	10.98	--	--	--	24.62	7.3	--	--	37.66	99.98
23	**Ein Makafa**	11.9	18.2	3.3	--	--	--	17.8	--	--	9.5	39.2	99.9
24	**Ein Makafa**	2.15	50.9	7.9	--	--	--	12.7	2.29	--	--	24.11	100.05