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HYDROGEOCHEMICAL STUDIES OF THE QUATERNARY GROUNDWATER AQUIFER IN EL SALHYIA AREA AND ITS VICINITIES, EAST NILE DELTA, EGYPT

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ABSTRACT

The present study discusses the hydrogeochemical characteristics of the Quaternary groundwater aquifer in Al-Salhia area. The study is based on the field and laboratory measurements. The Quaternary aquifer is mainly composed of sand and sandstone intercalated with clay and shale lenses. The agricultural activities and irrigation system has great impact on groundwater levels and water quality of the Quaternary aquifer in the study area.

Groundwater quality of the Quaternary aquifer has a wide range from fresh, fairly fresh, brackish to slightly saline water. The freshwater and fairly fresh water with salinity contents ranging from 622.7 to 1469.53 mg/l which indicated meteoric water origen is suitable for irrigation purposes. This water represents localities that suggest the recharge from surface water (El Ismailyia, salhyia and El Kassara canals).

The brackish and slightly saline water with salinity contents ranging from 1565.34 to 2872.95 mg/l which indicates the effect of leaching and dissolution of the aquifer material and over pumping processes is unsuitable for irrigation purposes.

The abnormal high saline water which represented by a well in the south west of the study area may be due to the upward leakage of the underline Miocene aquifer saline water

Key words: Quaternary, groundwater, aquifer, Al-Salhia>

INTRODUCTION

Land reclamation projects in the desert region are of vital importance for development of countries. Egypt governments do a great effort to increase the land reclamation. Heavy investments have been made to turn territories of the unproductive desert into green productive areas to survive the highly increasing rate of population. One of these areas is Al Salhia. It is located north Ismalyia canal and bounded by latitudes 30° 32` and 30° 40` N and longitudes 31°48`and 32°03`E, with the total area of about 106 km^2 (Fig 1). The area of study occupies a portion of the desert belt of Egypt. Its climate is characterized by a hot summer and a short rainy winter. The relative humidity is higher in winter than in summer, while the evaporation intensity is generally higher in summer than that in winter. The maximum value of rainfall are recorded in January at El Salhia station (7.2 mm./day) and the minimum value is recorded in June, July, August and September (Zero mm./day) at all station.

Surface water and groundwater are the main sources for irrigation activities, surface water represented by Ismalyia, Salhia canals and its branches (Fig. 1). The Quaternary groundwater aquifer represents the main sources of the groundwater in the study area. The uncontrolled uses of the groundwater causes large drawdown in groundwater level and change the groundwater qualities.

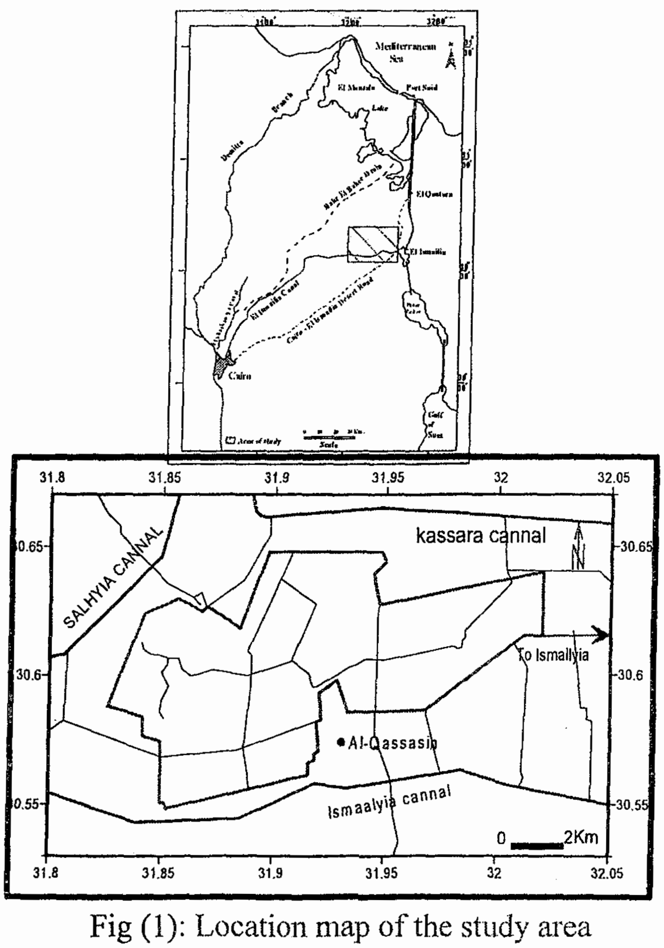


Fig (1): Location map of the study area

GEOLOGICAL SETTING

Geology of the eastern part of the Nile Delta has attracted the attention of many authors. Among them are the works of Shukri and Ayouti (1956), Said and Beheri (1961), Shata (1965), El Fayoumy (1968), Shata and El Fayoumy (1970), El Shazly et al. (1975), Hefny (1980) and Moussa (1990). The concerned area is natural extension of the Nile Delta it is a part of Belbies-El Tell El Kabier-El Salhia old deltaic plains (Fig. 2). These plains occupy almost low relief areas that lying to the east of the Nile Delta flood plain and extended to the Suez Canal district to the east. These plains are bounded in the south by Ankabia-Iwaibid structural plain and Gebel Mokattam--Ataqa structural plateau. Lake El-Manzala and lacustrine plain in the north. Lithostratigraphy, the area east of the Nile Delta is essentially occupied by sedimentary succession belonging to Tertiary and Quaternary Ages. Tertiary rocks are represented by Eocene, Oligocene, Miocene and Pliocene rocks. Eocene rocks are formed of shallow marine fossiliferous chalky, dolomitic sandy and marly limestone.(Fig. 4).

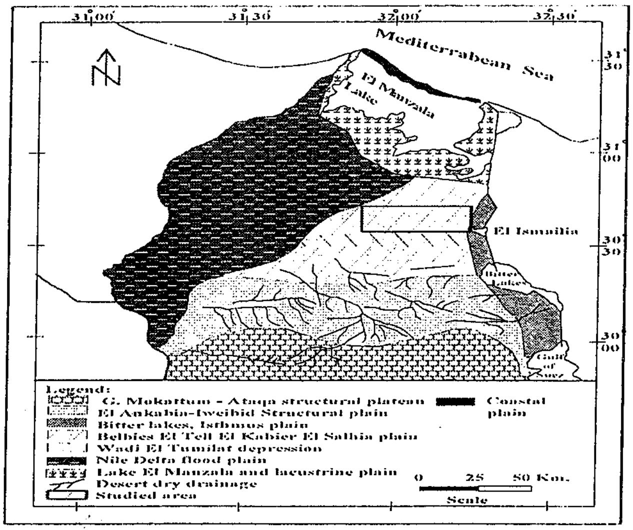


Fig (2): Geomorphological map of the area east of the Nile delta (After Shata 1979)

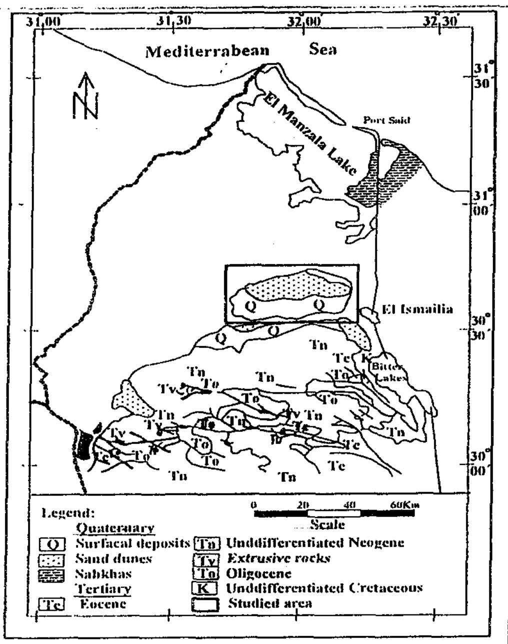


Fig (3) : Geological map of the study area (after geological map of Egypt 1971)

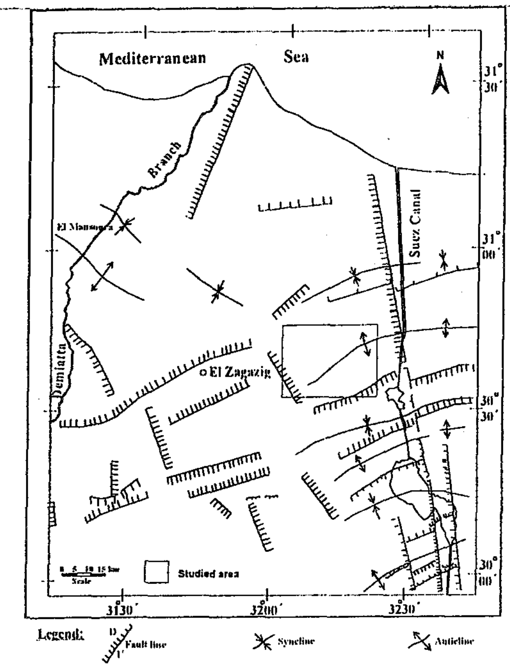


Fig (4): Compiled structural map of the area east of the Nile Delta (after El-Dairy, 1980)

Miocene rocks exposed on the surface and they are represented by El Shatt Formation (south of the Bitter lakes) and El Hommath Formation (west of the Gulf of Suez), they are composed of sandy limestone and sandy marls of shallow marine origin. Pliocene rocks are exposed on the surface in the area northwest of Cairo along the margins of the Heliopolis Basin.

Quaternary deposits have a wide distribution over the study area, they are represented by old deltaic deposits which are composed of fluviatile coarse quartz sand, cherty flinty pebbles and igneous fragments with few occasional fossil wood remains and young aeolian deposits composed of fine to coarse quartz sand with remarkable variable thickness.

The sedimentary succession in the study area is strongly affected by structural elements. The regional geological structure of the study area increases the thickness of the Quaternary aquifer of 3 m/km towards north Gad (1995). it ranges from 300 to 400 m. Faults and folds are the most conspicuous structural elements affecting the landscape in the study area. Faults are dominantly represented by an NE-SW and NW-SE directions of normal type (Fig. 4). Vertical displacement along these faults varies from few meters to hundred meters. The relationships between the subsurface lithology of Al Salhia area are shown on geologic cross sections B-B' and C-C' (Fig. 5).

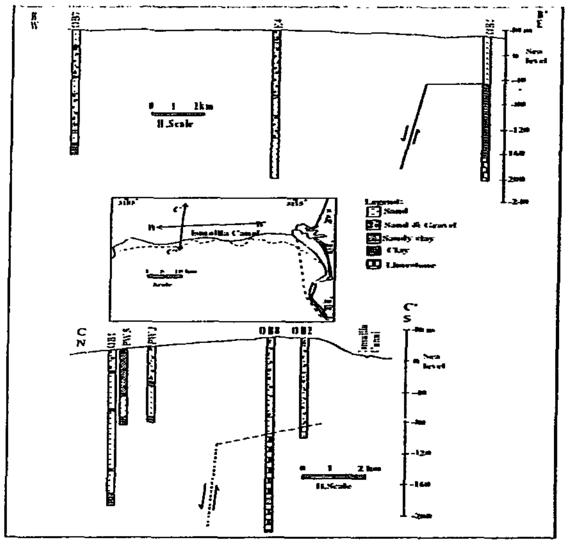


Fig. (5): Geological cross sections B-B' & C-C' inEl-Salhyia El Gidida–Abu Sweir area (after Gad, 1995).

The two cross sections illustrate the presence of fault zone which trends approximately through the south west of the area of study (Gad, 1995). Surface folds are detected out the area of study at Gebel Shubrawit, Gebel Iwiebid and Gebel Umm Ragm Fig.(4). In the subsurface, folds are detected by geophysical methods in the Abu Hammad and Abu Sultan deep wells.

HYDROGEOLOGICAL SETTING

The Quaternary water bearing formation constitutes the main source of groundwater aquifer in the study area. It is mainly composed of sand and gravels intercalated with clay and shale lenses Fig (7 and 8). The Quaternary water bearing formation rest directly on Pliocene clay and Miocene sandy limestone (Fig. 6).

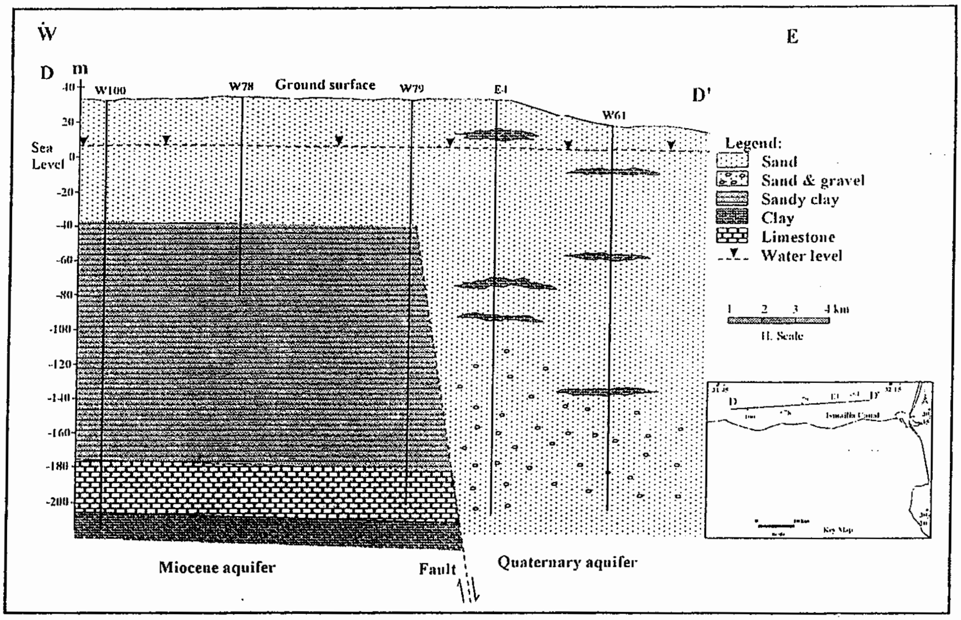


Fig. (6) Hydrogeological cross section (after Gad, 1995).

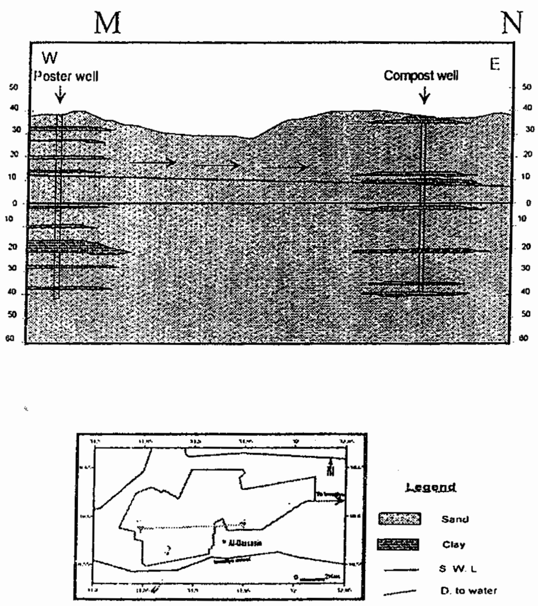


Fig. (8): Hydrogeological cross section
M--N in W--E direction

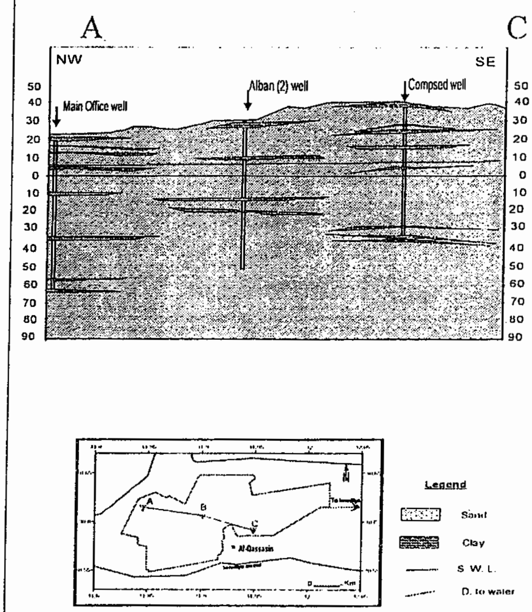


Fig. (7): Hydrogeological cross section
(A--B-C) in NW- SE direction

The saturated thickness of the Quaternary aquifer is strongly affected by normal faults with downthrown sides towards the east, this lead to increases the thickness toward north, northeast, it ranges from 300 m to 400 m in the study area while it reaches more than 900 m in the north near the Mediterranean Sea (Fig.6 and 9).

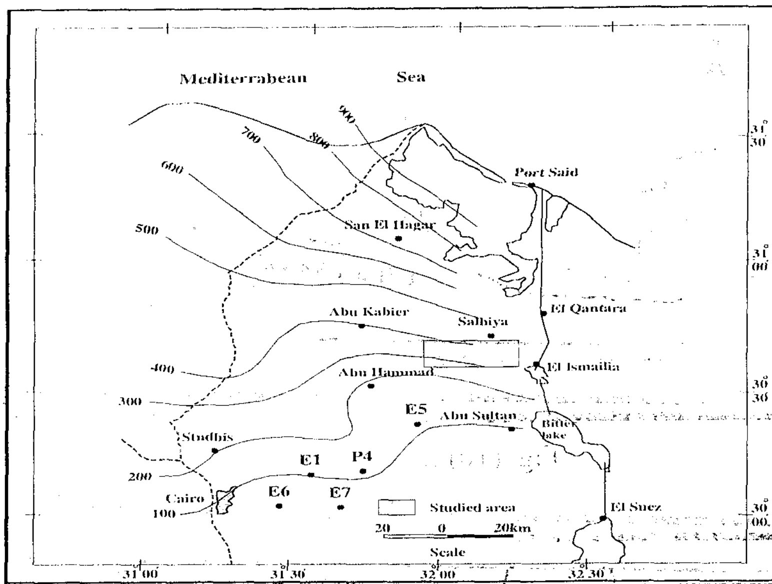


Fig. (9) Quaternary aquifer thickness contour map of the East Nile Delta (after Hefny, 1980).

Ismalyia and El Salhyia canals in addition to excess irrigation water represent the main recharge resources of The Quaternary aquifer in the study area while pumping groundwater through productive drilled wells represents the main discharging sources. The Quaternary aquifer is hydraulically connected with the underlain Miocene saline water aquifer through deep seated normal faults; this may be causes local vertical upward leakage of Miocene saline water. Depth to water and groundwater levels were measured of 29 drilled wells tapping the Quaternary aquifer. Depth to water shows wide range from 9 to 40 m. In general it records small depths at low topographic areas (less than 9 m), while it records large depths to water at high_topographic are ranges from 15 to 40 m water levels range from +6 in the southwest to +3.2 above main sea level (amsl) in the northeast. The groundwater flow is from southwest and northeast local groundwater flow and ground water depleted area were appeared especially at over pumping areas.

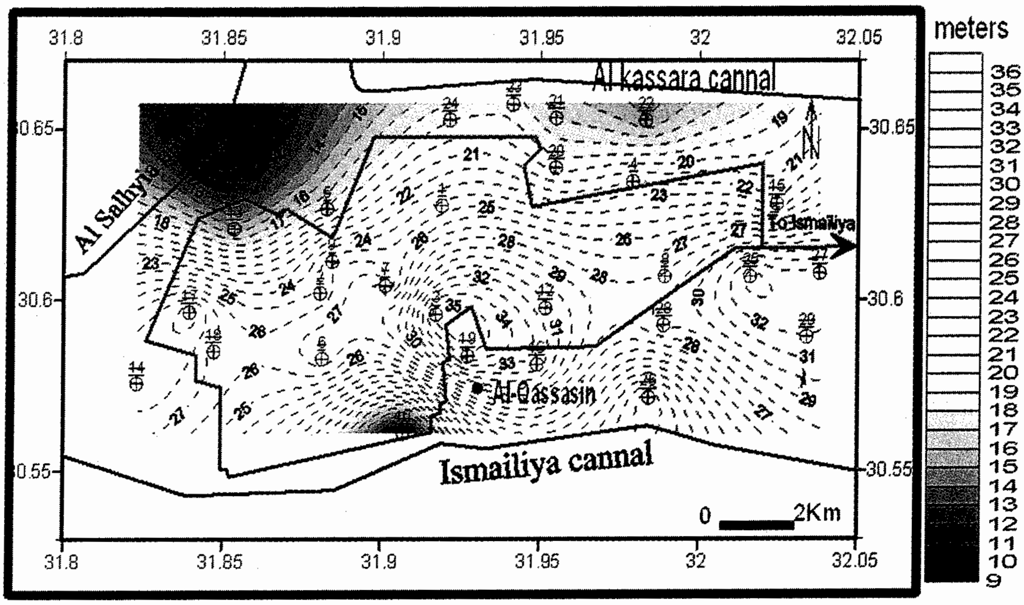


Fig. (10) Depth to water map

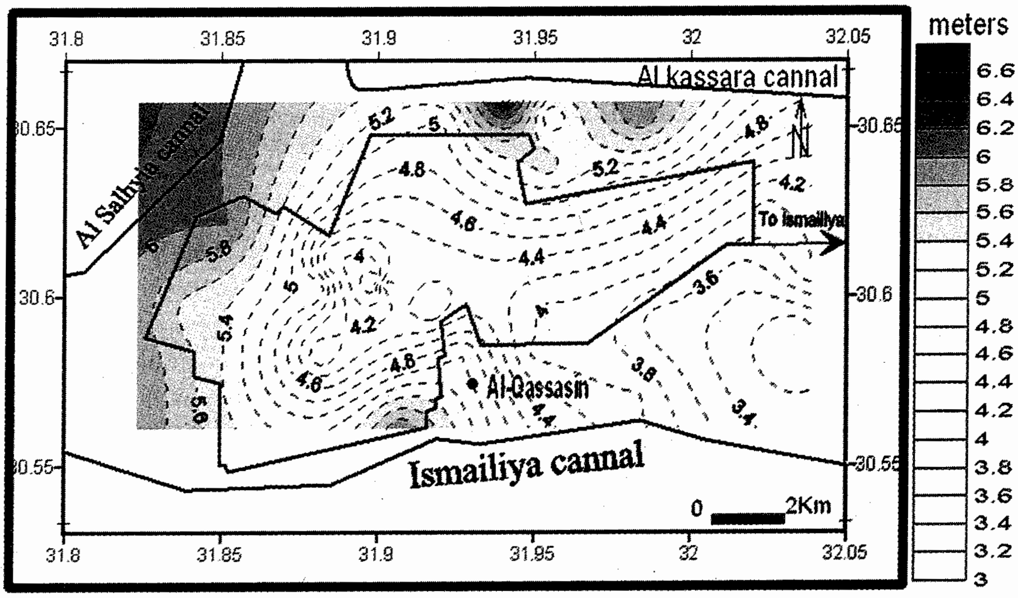


Fig. (11) Water level map

HYDROCHEMICAL ASPECTS

Hydrogeochemical characteristics of the Quaternary aquifer in the study area were discussed through the results of the chemical analyses of 29 groundwater samples collected during field trip in May 2007 (Fig. 8 and Table 2).

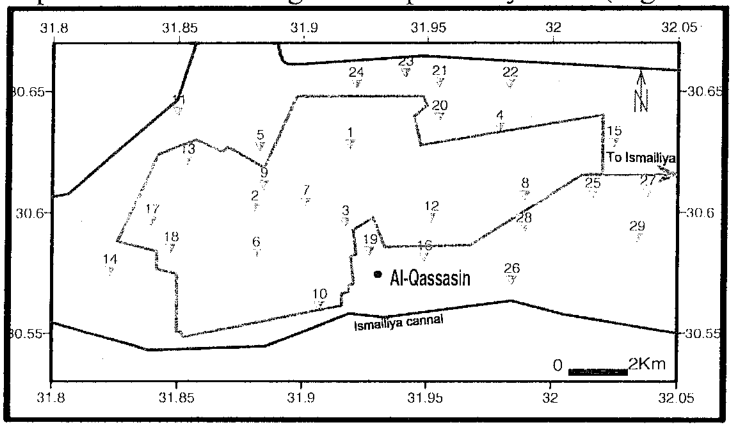


Fig. (12) Location map of groundwater samples

Major cations (Na^{+}, K^{+}, Ca^{++} and Mg^{++}) and anions (CO_3^{--}, HCO_3^{-}, SO_4^{--} and Cl^{-}) are determined and reported in Table (1). The analytical data were interpreted using numerical and graphical methods.

TOTAL DISSOLVED SALTS (TDS)

Salinity content of groundwater of the Quaternary aquifer has a wide range from fresh, fairly fresh, brackish to slightly saline water. The freshwater and fairly fresh water with salinity contents ranging from 622.7 to 1469.53 mg/l which indicated meteoric water origen is suitable for irrigation purposes. This water represents localities that suggest the recharge from surface water (El Ismailyia, salhyia and El Kassara canals). The brackish and slightly saline water with salinity contents ranging from 1565.34 to 2872.95 mg/l which indicates the effect of leaching and dissolution of the aquifer material and over pumping processes is unsuitable for irrigation purposes. The abnormal high saline water which represented by a well in the south west of the study area may be due to the upward leakage of the underline Miocene aquifer saline water. Salinity distribution map shows that there is a significant increase in the salinity contents towards the middle part of the study area indicating a probable recharge from deep seated Miocene aquifer as well as the over pumping of groundwater for irrigation.

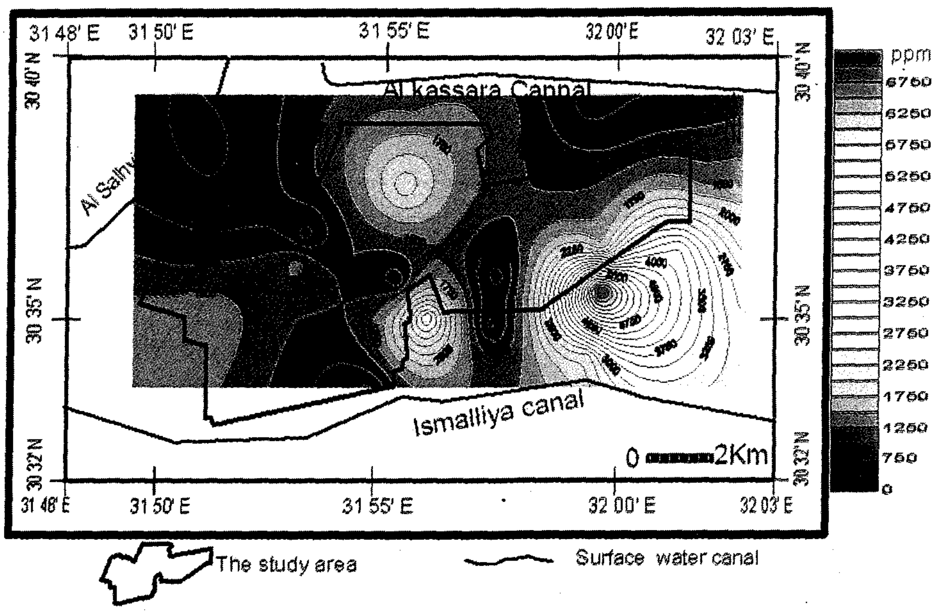


Fig (13) Salinity distribution map of the groundwater in the study area (El-Salhyia Farm and its vicinities - May- 2007).

The frequency distribution of T.D.S figure (11) shows that 27.59% have salinity ranging between 500 and 1000 ppm, 34.50% between 1000 and 1500 ppm, 13.87% between 1500 and 2000 ppm, 10.30% between 2000 and 2500 ppm, 13.80% of the sampled wells have salinity more than 2500 ppm.

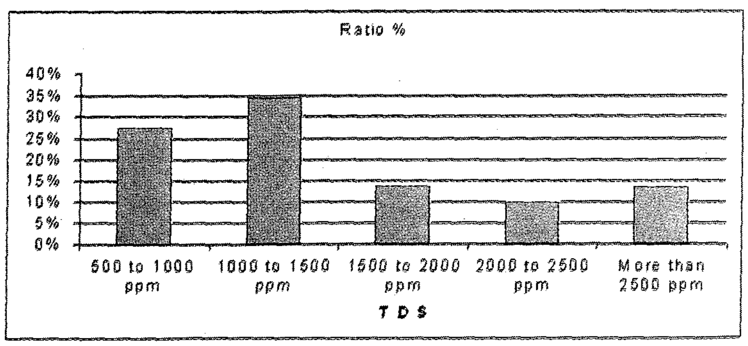


Fig (14): The frequency distribution histograms of T.D.S

On the other hand, the groundwater salinity reach to 7043.4 ppm (well No. 28) located on the faulting zone (see hydrogeological cross section (Fig. 6) indicated upward seepage of Miocene aquifer through the faulting planes and from excess irrigation water and poor drainage as well as the presence of clay lenses and lagoonal deposits dominating the eastern low lands. salinity display a poorly linear relationship with bicarbonate with correlation coefficient (0.00), low linear relationship with Potassium with correlation coefficient (0.159), moderately linear relationship with magnesium ions with correlation coefficient (0.576).

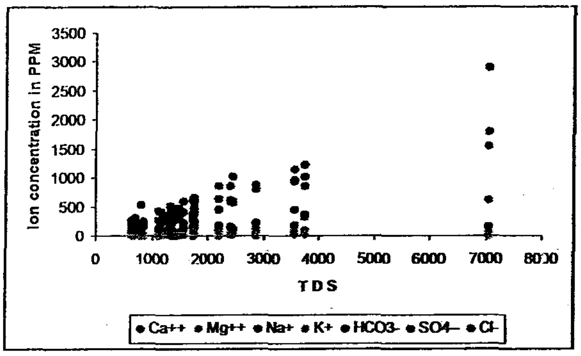


Fig (15): relationship of salinity contents with other ions (in mg/l)

DISTRIBUTION OF HYDROCHEMICAL ELEMENTS OF THE QUATERNARY AQUIFER

Regarding to cations, the concentration of K^+ is generally less than 20 ppm. It ranging from 3 to 18.4ppm except the well No. (5) it reaches (39 ppm). The sodium ion (Na^+) is the most important alkali metal in natural water. It represents the dominant cation in the majority of the analyzed groundwater samples (82.75% of the total samples). The concentration in the investigated water samples varies widely from 123ppm to 1800ppm (Table 1). Magnesium represents the second dominant cations in 17.24% of the total groundwater samples. The concentration of (Mg^{++}) is generally less than (113 ppm). It ranges from 7.29ppm at well No.(14) to 112.8 ppm at well No. (2).The lower values are detected near the irrigation canals. It is clear that Magnesium ion (Mg^{++}) concentration generally increase towards the east directions. Calcium is generally less than 620 ppm Fig (23). The calcium concentration of ion (Ca^{++}) in the water sample varies widely from (20 ppm) to (620 ppm). The concentration of calcium ion (Ca^{++}) increase as will as the sodium ion (Na^+) towards east direction, this indicates the effect of leaching and dissolution processes of the aquifer material. Regarding to the anions, the concentration of chloride ion (Cl^-) ranges from 92.3 ppm to 2900 ppm while the concentration of sulfate (SO_4^{--}) ion ranging from 84.4 ppm to 1550 ppm. The concentration of bicarbonate were ranging from (122 ppm) to (524.6 ppm) table (1).

Table (1): The chemical analyses of groundwater samples (May- 2007).

Well No.	EC µMhos/cm	pH	TDS (mg/l)	T. Hardness	Cations (mg/l)				Sum. Cat.	Anions (mg/l)			Sum An.
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}		HCO_3^-	SO_4^{--}	Cl^-	
1	3826.25	8.2	2448.8	675	104	100.8	584.2	10.92	39.16	122	1015.68	572.26	39.28
2	2445.84	7.8	1565.34	824	144	112.8	216.2	12.48	26.18	134.2	600.96	411.8	26.32
3	1311.92	7.8	839.5	268	44	38.4	197.8	7.8	14.15	158.6	252.1	220.1	14.05
4	1730.25	8	1107.36	337	40	57.6	257.6	7.02	18.11	122	421.44	262.7	18.18
5	1798.28	8	1150.9	317	28	60	266.8	39	18.93	244	406.8	228.3	18.91
6	1933.14	7.7	1237.21	420	104	38.91	280	12.8	20.89	264	341.5	328	20.69
7	1957.47	8.00	1252.78	420	96	43.78	285	12.8	21.11	280	347.2	328	21.07
8	2824.38	7.9	1807.6	600	136	63.2	420	18.4	30.72	480	200.1	660	30.65
9	989.08	8.4	633.01	213	20	39.6	142.6	10.12	10.71	140.3	258.24	92.3	10.28
10	1096.47	8.2	701.74	228	36	33.6	170.2	4.68	12.08	268.4	188.16	134.9	12.12
11	1079.08	7.6	690.61	318	64	38.4	133.4	3.12	12.23	305	156.48	142.71	12.28
12	972.97	7.55	622.7	139	20	21.6	184	3.9	10.87	244	100.8	170.4	10.90
13	1245.67	6.9	797.23	513	120	51.84	105.8	5.46	14.99	524.6	86.4	165.43	15.06
14	2717.64	8.54	1739.29	190	64	7.29	570	4	28.68	252	400	568	28.48
15	2244.5	8.68	1436.48	210	48	21.8	455	4	24.07	283.5	300	465.93	24.03
16	1038.52	8.7	664.65	310	92	19.4	123	7	11.71	220.5	100	213	11.70
17	2073	8.8	1326.72	520	160	29.1	285	8	22.97	283.5	197	505.87	23.01
18	2687.34	8.72	1719.9	659	172	55.9	370	9	29.50	283.5	350	621.25	29.45
19	5558.91	8.5	3557.7	829	184	89.9	970	12	59.06	441	945.3	1136	58.94
20	2100.11	8.66	1344.07	360	112	19.4	365	5	23.18	409.5	220.8	417.12	23.07
21	2109.77	8.56	1350.25	210	56	17	430	4	22.99	441	250	372.75	22.94
22	1044.39	8.55	668.41	130	32	12.1	200	3	11.36	252	140	155.31	11.42
23	2272.27	8.67	1454.25	210	56	17	460	4	24.30	378	320	408.25	24.37
24	2296.14	8.75	1469.53	250	64	21.8	450	4	24.65	315	306.3	465.93	24.68
25	5843.75	8.69	3740	1239	336	97.2	850	17	62.15	378	1030.5	1220.3	62.06
26	3734.06	8.64	2389.8	640	160	58.3	605	18	39.54	157.5	600	869.75	39.60
27	3429.02	8.35	2194.57	460	108	46.2	630	5	36.71	189	450	860.87	36.74
28	11005.23	8.74	7043.35	1898	620	85.1	1800	9	116.43	157.5	1550	2900.5	116.65
29	4488.98	8.08	2872.95	580	128	63.2	800	9	46.60	220.5	875	887.5	46.86
Qassasin	390	8.3	249.6	112	34	6.68	32.2	39	4.64	170.8	1.92	46.25	4.14
Abu Saweer	380	7.8	243.2	112	36	5.4	31.41	39	4.60	172.3	1.92	48.28	4.23
Seuz Canal	58300	7.4	37312	3591	1280	96	11500	390	581.77	176.9	1876.8	19170	582.57

ION DOMINANCE AND WATER CHEMICAL TYPES:

Semi logarithmic graph (Schoeller, 1956) was used to identify ion dominance and main water type. It showed that Sodium is the most dominant cation followed by magnesium and Calcium ($Na^+ > Ca^{++} > Mg^{++}$) (figs. 16) and (table 2). Regarding anions, chloride is the most dominant anions followed by sulfate of the majority of samples ($Cl^- > SO_4^{--} > HCO_3^-$). The presence of ion sequence ordering of ($Na^+ > Ca^{++} > Mg^{++}$) / ($Cl^- > SO_4^{--} > HCO_3^-$) reflects meteoric water origin while the presence of ion ordering of ($Ca^{++} > Na^+ > Mg^{++}$) / ($Cl^- > SO_4^{--} > HCO_3^-$) at some localities reflects leaching processes of clay and gypsum as well as mature phase of groundwater evolution (Dahab, 2003).

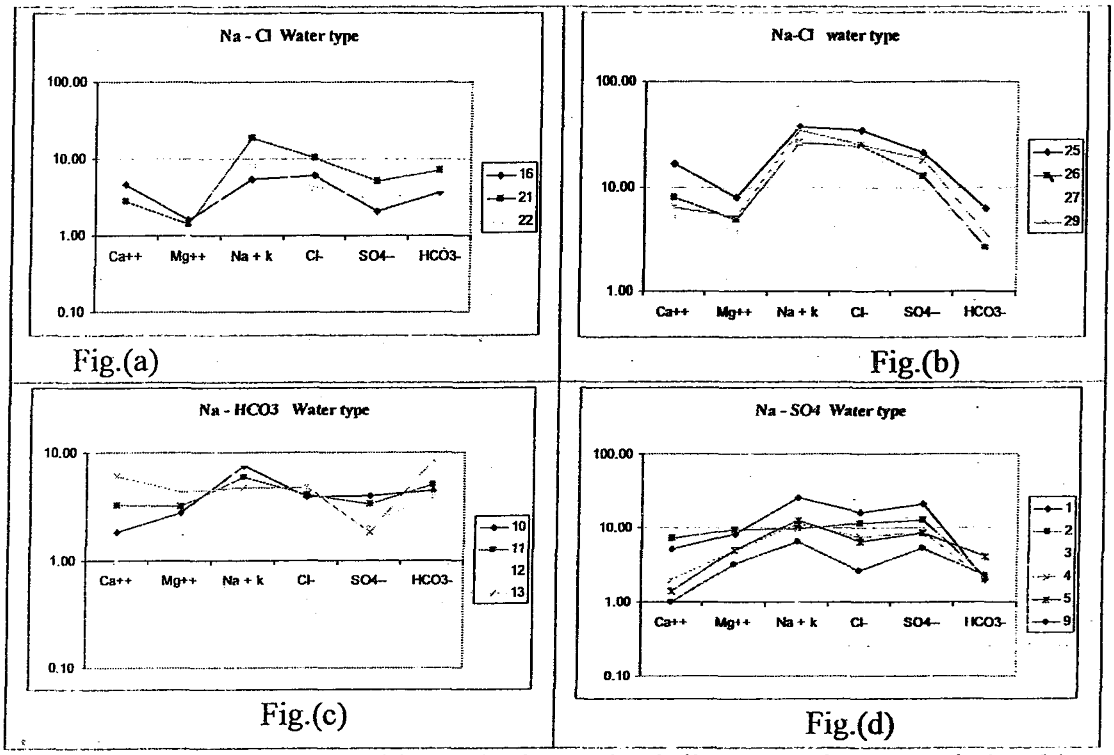


Fig. (16) Schoeller Semi logarithmic graph (Salinity – major ions relationship) in the groundwater of the Quaternary aquifer in El Salhia area.

They include the upward leakage of Miocene groundwater in the west, leaching process of evaporites facies and saline soil within the aquifer matrix to the east, irrigation canals and the return flow of irrigation water. On the other hand, Ca & Mg are little significant, while HCO_3 is not significant with salinity.

According to the concentration of cation and anion in the groundwater samples of the Quaternary aquifer in the area of study (El-Salhyia Farm and its vicinities), the following main orders of ions and consequent chemical types are recognized:-

Table (2): Ion dominance and water chemical types

Sample No.	Ion dominance	Chemical facie	Percentage (%
2 and 3	$So_4^{--} > Cl^- > Hco_3^- \ \& \ Na^+ > Ca^{++} > Mg^{++}$	So_4 - Na	10.34 %
1 and 4	$So_4^{--} > Cl^- > Hco_3^- \ \& \ Na^+ > Mg^{++} > Ca^{+}$	So_4 - Na	6.9 %
6,7,14,15,18,19,25, 26,27,28 and 29	$Cl^- > So_4^{--} > Hco_3^- \ \& \ Na^+ > Ca^{++} > Mg^{++}$	Cl - Na	34.48 %
10 and 11	$Hco_3^- > So_4^{--} > Cl^- \ \& \ Na^+ > Ca^{++} > Mg^{++}$	Hco_3^- - Na	6.9 %
12	$Hco_3^- > So_4^{--} > Cl^- \ \& \ Na^+ > Mg^{++} > Ca^{++}$	Hco_3^- - Na	3.45 %
8,17,20,23 and 24	$Cl^- > Hco_3^- > So_4^{--} \ \& \ Na^+ > Ca^{++} > Mg^{++}$	Cl - Na	17.24 %
5 and 9	$So_4^{--} > Hco_3^- > Cl^- \ \& \ Na^+ > Mg^{++} > Ca^{++}$	So_4 - Na	6.9 %
16,21 and 22	$Hco_3^- > Cl^- > So_4^{--} \ \& \ Na^+ > Ca^{++} > Mg^{++}$	Hco_3^- -Na	10.34 %
13	$Hco_3^- > Cl^- > So_4^{--} \ \& \ Ca^{++} > Na^+ > Mg^{++}$	Hco_3^- - Ca^{++}	3.45 %

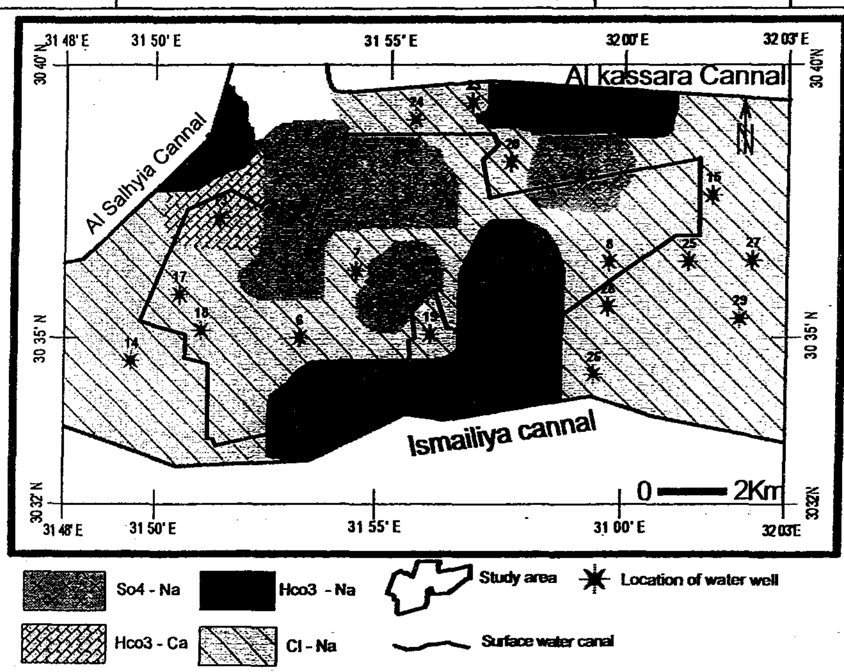


Fig. (17): zonation map of water chemical types

The correlation of this map with the salinity distribution map (Fig 4-15) with reference to the sources of recharge, can explained in the following points:

1) *SO4 – Na water type* is related to dissolution and leaching processes from the excess of irrigation water and the reaction with the aquifer material.
2) *HCO3 – Ca water type* indicated the meteoric origin and dissolution processes caused the excess of calcium element.
3) *HCO3 - Na water type* indicated that beside the meteoric origin, a recharge from surface water canal has been taken place due to its occurrence closed to these canals.
4) *Cl – Na water type* may be related to salt water intrusion which occurred from Suez canal or from upward leakage from the underline saline Miocene groundwater aquifer. This type of water has wide spreading in the study area due to the daily over pumping discharge for the agricultural projects in the area of study.

HYDROCHEMICAL COEFFICIENTS:

The relation between different major ions could be studied through the determination of some ion ratios. These ratios are helpful in detecting the previous hydrochemical processes affecting water quality such as leaching, mixing and ion exchange. The ratios rNa/rCl, rCl-rNa/rCl, rSo_4/rCl, rCa/rMg and rCl/rCo_3+$rHco_3$ were calculated (Table 3).

rNa/rCl:- The Na/Cl coefficient in the groundwater varies from 0.84 (well No.2) to 2.48 (well No.9) with an average of 1.66. It indicates excess sodium over chloride in most samples (82.75 % of total samples) which reflects meteoric water origin of groundwater. The remaining percentage (17.25% of total samples) has a value less than unity that reflects the action of dissolution and ion exchange processes.

rSo_4/rCl: The coefficient varies between (0.22) well No.(8) to (2.07) well No.(9) with an average of (1.14). It is generally less than unity in (79.3%) of total samples. While, it is more than unity in (20.7%). High sulfate indicate leaching of the presence of local terrestrial sulfate salts that dominate in aquifer material.

rCa/rMg:- The Ca/Mg coefficient dissolution in groundwater ranges from 0.28 well No. (5) to 5.32 well No.(14) with an average of 2.8. This means more calcium than magnesium which is recognized in about (72.4%) of total analyzed samples. The remarkable increase of this ratio over magnesium that reflect the recharge from surface water (of El-Ismaillyia canal El-Salhyia canal El-Kssara canal).

Table (3): Hydrochemical coefficients of groundwater sample

Well No.	Ion ratio				
	rNa/rCl	rSo_4/rCl	rCa/rMg	rCl-rNa/rCl	$rNa-rCl/rSo_4$
1	1.59	1.31	0.63	0.00	0.45
2	0.84	1.08	0.77	0.16	0.00
3	1.42	0.85	0.70	0.00	0.49
4	1.54	1.18	0.42	0.00	0.45
5	1.96	1.32	0.28	0.00	0.73
6	1.35	0.77	1.62	0.00	0.46
7	1.38	0.78	1.33	0.00	0.48
8	1.01	0.22	1.31	0.00	0.03
9	2.48	2.07	0.31	0.00	0.72
10	1.98	1.03	0.65	0.00	0.95
11	1.46	0.81	1.01	0.00	0.57
12	1.69	0.44	0.56	0.00	1.57
13	1.02	0.39	1.40	0.00	0.04
14	1.55	0.52	5.33	0.00	1.06
15	1.51	0.48	1.34	0.00	1.08
16	0.92	0.35	2.88	0.08	0.00
17	0.88	0.29	3.34	0.12	0.00
18	0.93	0.42	1.87	0.07	0.00
19	1.33	0.61	1.24	0.00	0.53
20	1.36	0.39	3.50	0.00	0.92
21	1.79	0.50	2.00	0.00	1.59
22	2.00	0.67	1.60	0.00	1.51
23	1.75	0.58	2.00	0.00	1.29
24	1.50	0.49	1.78	0.00	1.02
25	1.09	0.62	2.10	0.00	0.14
26	1.09	0.51	1.67	0.00	0.18
27	1.13	0.39	1.42	0.00	0.35
28	0.96	0.39	4.42	0.04	0.00
29	1.40	0.73	1.23	0.00	0.55

samples. They are rich in sulphate salts. These salts are the result of leaching and dissolution of sediments rich in evaporate salts (mainly gypsiferrous shale).

Group (2): include **NaCl, Na_2SO_4, $MgSO_4$, Mg $(HCO_3)_2$ and $Ca(HCO_3)_2$** this group represented in 8 water samples (3,5,8,9,10,11,14 and 20) represented 25% of total samples. They are rich in sulfate salts. These salts are the result of leaching and dissolution of sulfate sediments deposits rich in evaporate salts (mainly gypsiferrous shale). Also they are rich in bicarbonate salts that reflect the meteoric water origin.

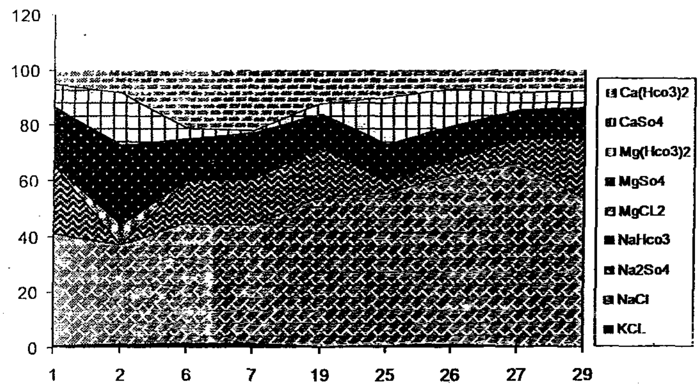


Fig.(18): Cross section show the change in hypothetical salts at wells (1,2,6,7,19,25,26,27 and 29)

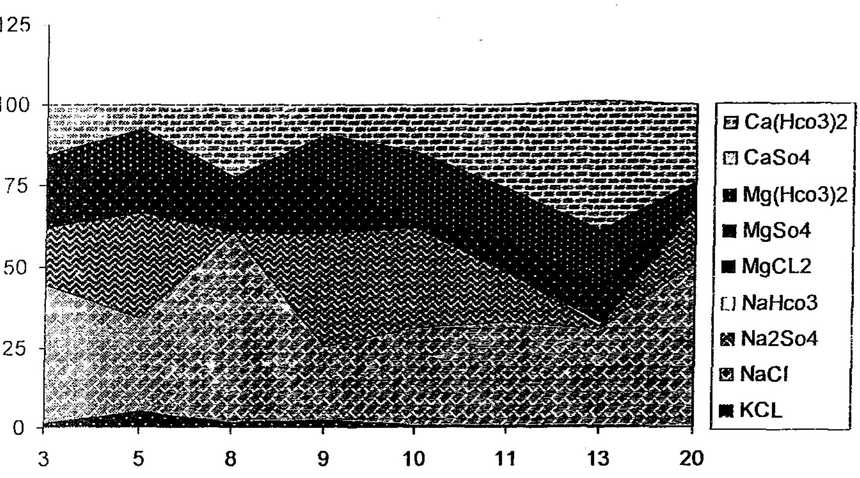


Fig.(19): Cross section show the change in hypothetical salts at wells (3,5,8,9,10,11,13 and 20)

Table (4): Hypothetical salt combinations of the quaternary aquifer in the study area.

Sampl e NO.	KCL %	NaCl %	Na2So 4 %	NaHco 3 %	MgCL 2 %	MgSo 4 %	Mg(Hco3)2 %	CaSo 4 %	Ca(Hco3) 2 %
1	0.71	40.37	24.49	0.00	0.00	21.17	0.00	8.17	5.08
2	1.22	35.9	0.00	0.00	6.99	28.44	0.00	19.09	8.35
3	1.4	42.76	18.01	0.00	0.00	19.35	2.98	0.00	15.51
4	0.99	39.75	22.09	0.00	0.00	26.15	0.00	0.00	11.02
5	5.27	28.78	32.5	0.00	0.00	12.30	13.77	0.00	7.38
6	1.57	43.14	15.13	0.00	0.00	15.32	0.00	3.89	20.95
7	1.55	42.35	16.35	0.00	0.00	17.06	0.00	0.90	21.79
8	1.53	59.2	0.25	0.00	0.00	13.34	3.58	0.00	22.09
9	2.42	22.9	34.97	0.00	0.00	17.34	13.06	0.00	9.31
10	0.99	30.4	30.86	0.00	0.00	1.46	21.42	0.00	14.87
11	0.65	32.15	15.27	0.00	0.00	11.26	14.56	0.00	26.14
12	0.92	43.15	19.25	11.17	0.00	0.00	16.34	0.00	9.17
13	0.93	30.04	0.65	1.28	0.00	11.29	17.15	0.00	39.93
14	0.36	55.89	29.25	1.95	0.00	0.00	2.09	0.00	11.13
15	0.43	54.24	25.99	0.00	0.00	0.00	7.45	0.00	9.94
16	1.53	45.66	0.00	0.00	4.14	9.48	0.00	8.31	30.88
17	0.89	53.94	0.00	0.00	7.16	3.26	0.00	14.56	20.19
18	0.78	54.54	0.00	0.00	4.16	11.42	0.00	13.32	15.78
19	0.52	53.83	17.58	0.00	0.00	12.52	0.00	3.29	12.26
20	0.55	50.44	18.02	0.00	0.00	1.91	4.97	0.00	24.12
21	0.45	45.36	22.69	13.27	0.00	0.00	6.08	0.00	12.15
22	0.68	37.66	25.51	13.35	0.00	0.00	8.76	0.00	14.04
23	0.42	46.82	27.34	8.16	0.00	0.00	5.75	0.00	11.51
24	0.42	52.82	25.84	0.70	0.00	0.00	7.27	0.00	12.95
25	0.70	54.75	4.71	0.00	0.00	12.86	0.00	17.00	9.98
26	1.16	60.78	5.74	0.00	0.00	12.12	0.00	13.69	6.50
27	0.35	65.75	8.90	0.00	0.00	10.35	0.00	6.25	8.43
28	0.20	67.22	0.00	0.00	2.7	3.31	0.00	24.36	2.21
29	0.49	52.92	21.73	0.00	0.00	11.15	0.00	6.00	7.71

HYPOTHETICAL SALT COMBINATIONS OF THE QUATERNARY AQUIFER IN THE STUDY AREA:

The combination between major ions in groundwater reveal the occurrence of sex groups of salt assemblages (Fig 18,19,20,21).

<u>Group (1):</u> include **$NaCl$, Na_2SO_4, $MgSO_4$, $CaSO_4$ and $Ca(HCO_3)_2$** this group represented in 8 water samples (1,6,7,19,25,26,27and 29) represented 25% of total

<u>Group (3):</u> **NaCl, Na_2SO_4, $NaHCO_3$, $Mg(HCO_3)_2$, and $Ca(HCO_3)_2$** this group represented in 7 water samples (12,14,15,21,22,23 and 24) represented 24% of total samples. rich in bicarbonate salts that reflect the meteoric water origin and suggests recharge from of El-Ismaiiliyia, El-Salhyia and El-Kssara canals samples. Moreover the presence of (**$NaHCO_3$**) indicate recent recharge.

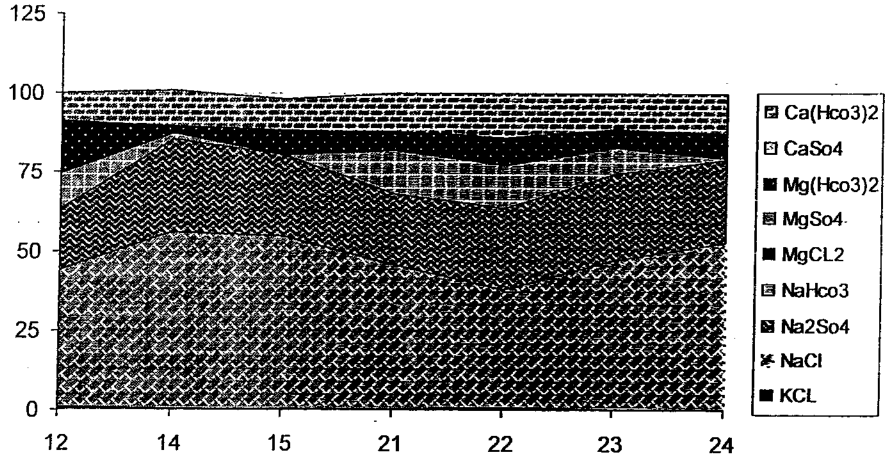


Fig.(20): Cross section A-A show the change in hypothetical salts at wells (1,2,6,7,19,25,26,27 and 29)

<u>Group (4):</u> **NaCl, $MgCl_2$, $MgSO_4$, $CaSO_4$, and $Ca(HCO_3)_2$** detected in 4 water samples (16, 17,18 and 28) represented 14% of total samples. They are rich in sulfate and chloride which reflect the leaching processes of logonel deposits.

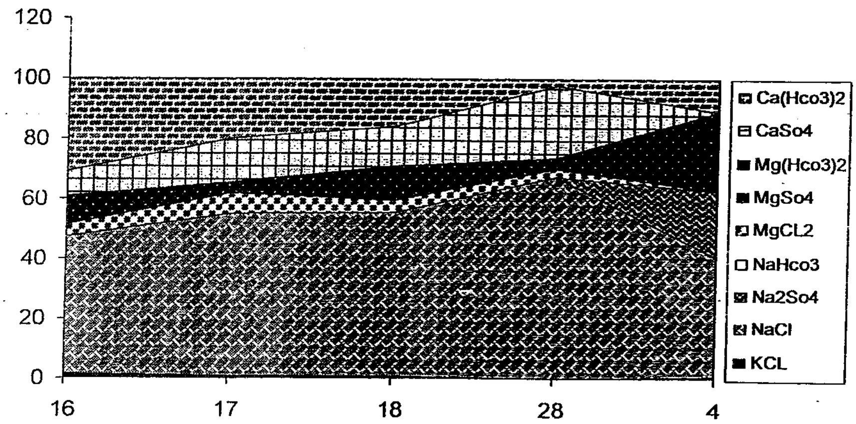


Fig.(21): Cross section A-A show the change in hypothetical salts at wells (1,2,6,7,19,25,26,27 and 29)

GROUNDWATER CLASSIFICATION ACCORDING TO PIPER (1944):

The projection of chemical composition of water on the diamond field (fig.22) revealed that the most of water chemical compositions of samples (25 samples) are plotted in subarea (7) which reflects secondary salinity properties characterized by Na^+, K^+ and SO^-_4, Cl^- and sodium chloride salts and the characteristic hypothetical salts are Na^+, K^+ chloride and sulfate. Three samples (wells No. 3, 11 and 16) are plotted in subarea (9) where no one of the cation-anion parts exceed 50% (fresh water) which reflects salinity properties characterized by Ca^{++}, Mg^{++}, SO^-_4, Cl^- and the characteristic hypothetical salts are Ca^{++}, Mg^{++}, chloride and sulfate. Only one sample (well No. 13) is plotted in subarea (5) which reflects salinity properties characterized by Ca^{++}, Mg^{++}, HCO_3 and the characteristic hypothetical salts are Ca^{++}, Mg^{++}, bicarbonate. Also only one sample (well No.2) is plotted in subarea (6) which salinity properties characterized by Ca^{++}, Mg^{++}, SO^-_4, Cl^- and the characteristic hypothetical salts are Ca^{++}, Mg^{++} chloride and sulfate. The study of groundwater genesis of the Quaternary aquifer under (El Salhyia farm and its vicinities) mainly depends on the geological history of the area under study. The variation in the chemical composition of the groundwater is mainly due to the variation in the lithology and the geological condition of local areas.

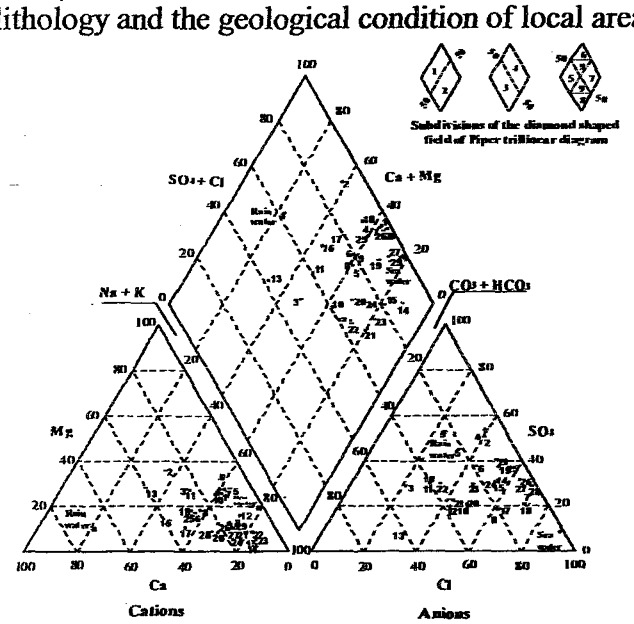
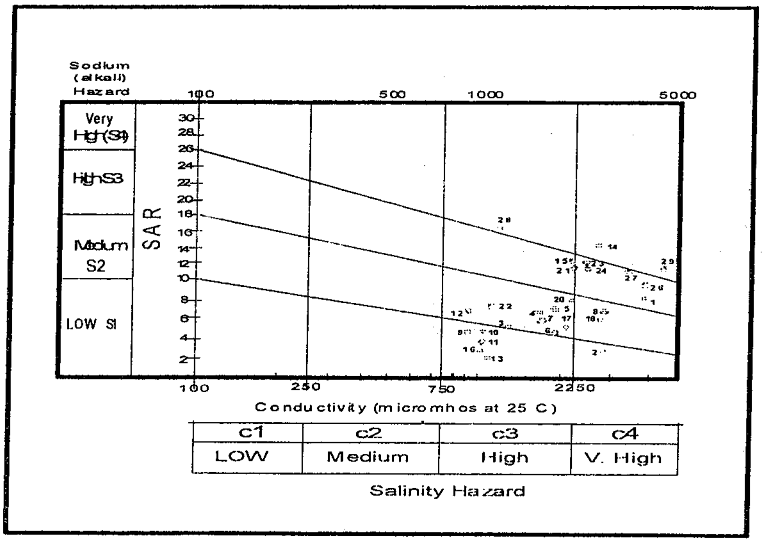


Fig (22) Piper-linear diagrams for the groundwater chemical analysis of quaternary aquifer in the area of study (El-Salhyia Farm and its vicinities)

EVALUATION OF GROUNDWATER FOR IRRIGATION PURPOSE

The groundwater represents an important source for irrigation in (El Salhyia farm) and the most important source for its vicinities. Water quality, soil type, and cropping practices all play a role in successful irrigation. Good - quality water permits maximum yields consistent with proper soil and water management. Generally the total salinity and Sodium hazard (SAR) are the important ones in the evaluation of Water quality for irrigation purposes. The diagram gave an assessment of water in which TDS is expressed as EC is plotted against sodium adsorption ratio (SAR), (Fig.21). The resulting 16 fields give an indication of the probability of possible excessive salinity and undesirable ion exchange and classified the water for irrigation purposes according to sodium adsorption ratio (SAR), electrical conductivity and sodium percentage.



(Fig.23):Groundwater Evaluation for Irrigation (after US Lab. (1954)

The samples of the wells { (9,10,11,13,16) (3,5,6,7,12,17,20) (15,21) (28)} lie in the C_3 field. The samples of the wells{ (2) (8,18) (1,23,24,26) (14,27,29) } lie in the C_4 field. The samples of the wells (2,9,10,11,13,16) lie in the S_1 field, the samples of the wells (3,4, 5, 6,7,8,12,17,18,20,22) lie in the S_2 field. The samples of the wells (1,15,21,23,24,26,27) lie in the S_3 field. The samples of the wells (14,28,29) lie in the S_4 field. Two underground water well samples present out side of this scale (well No.(19) EC5558.91μ mhos/m and well No.(25) EC.5843.75μ mhos/m).

CONCLUSIONS

1- Good drainage system should be constructed in the areas suffering from water pond and water logging to dewater the excess irrigation water and protect the old cultivated land from destruction.

2- Applying enforcement laws for completely stop the traditional irrigation and apply the modern irrigation systems (drops and shower) to save more water to increase the cultivated land and prevent excess irrigation water from infiltration and seepage to the low topographic land.

3-Public awareness is effective tool to protect groundwater as human activities for the main threat of polluting groundwater, plant the low dependent water plants and plant the salt tolerant crops in the areas suffering from high saline groundwater.

4-Geophysical exploration should be applied to locate the best sites for drilling new wells and determine suitable depths.

REFERENCES

El Fayoumy, I. F. (1968): "Geology of groundwater supplies in the region east of the Nile Delta". Ph. D. Thesis, Fac. of Sci., Cairo Unvi. 201p.

El Shazly, E. M., Abdel Hady, M. A., El Shazly, M. M., El Ghawabby, M. A., El Kassas, I. A., Salman, A. B. and Morsi, M. A. (1975):"Geological and groundwater potential studies of El Ismailya master plan study area". Remote Sensing Research Project, Academy of scientific Research and Technology, Cairo, Egypt, 24p.

El-Dairy, M. D. (1980): "Hydrogeological studies on the eastern part of Nile Delta using isotope techniques". M. Sc. Thesis, Fac. of Sci., Zagazig Unvi. 233p.

Gad, M.I. (1995): "Hydrogeological studies for groundwater reservoirs, East of the Tenth of Ramadan city and vicinities". M.Sc. Thesis,. Fac. of Sc., Ain Shams Univ., Cairo, Egypt, P.

Hefny, K. (1980): "Groundwater in the Nile Valley". Ministry of Irrigation. Water Research Center. Groundwater Research Inst. (in Arabic); 120p.

Moussa, B.M. (1990): "Petrology and soil Genesis of the surface Quaternary deposits, East of the Nile Delta, Egypt". Ph. D. Thesis, Fac. of Sci., Ain Shams Unvi. 391p.

Piper, A. M., (1944): "A graphic representation in the geochemical interpretation of groundwater analyses". American Geophysical Union Transactions, U.S.A., Vol. 25, pp. 914-923.

Said, R. and Beheri, S. (1961): "Quantitative geomorphology of the area East of Cairo". Bull. Soc. Geographic, Egypt, pp. 121-132.

Sallouma, M. K. M. (1983): "Hydrogeological and hydrogeochemical studies east of Nile Delta, Egypt". Ph. D. Thesis, Fac. of Sci., Ain Shams Unvi. 166p.

Shata A. A. and El Fayoumy, I. F. (1970): "Remarks on the regional geological structure of the Nile Delta". Symposium Hydrology of Delta, UNESCO, Vol. I., pp. 189 – 197.

Shata, A. A. (1965): "Geological structure of the Nile Delta". Journ. Of Engin. Cairo, (in Arabic), pp. 1-3.

Sukri, N.M. and El Ayouti, M.K. (1956): "The geology of Gebel Iwiebid, Gafra area, Cairo Suez district". Bull Soc. Geographic, Egypt, pp. 67-71.