

**INFLUENCE OF THE HYDROLOGIC FLOW
PATTERN AND AQUIFER MATERIALS ON WATER
QUALITY AND MINERAL CONTENTS: CASE
STUDY, NILE DELTA, EGYPT .**

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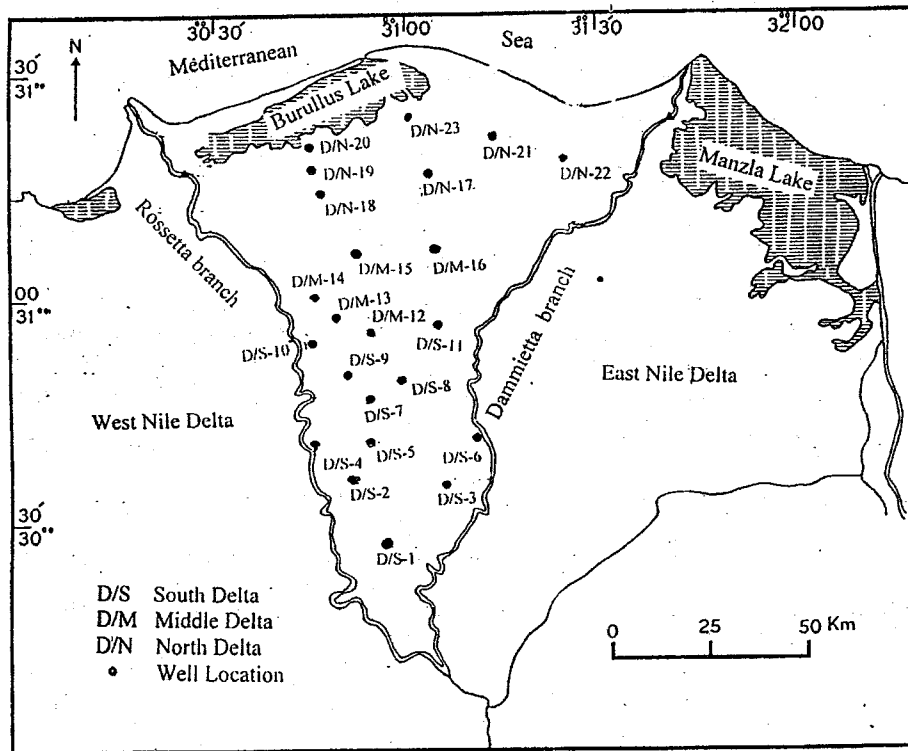
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Abstract.

The present work discusses diagenetic changes of groundwater during its passage through the aquifer. The Nile Delta area was selected as a field model. The hydrologic flow pattern and aquifer materials are the main factors affecting groundwater quality in the Nile Delta. They were strongly affected by the Nile river stages and changes in sea water levels. The southern and middle parts of the Nile Delta were subjected to successive fresh Nile water invasion especially during Early and Middle Pleistocene times, the groundwater tapped in these parts was exposed to excessive leaching and dilution, it shows low salinity contents. The northern part was strongly subjected to excessive sea water invasion with less fresh Nile water leaching especially during Late Pleistocene and Holocene times, groundwater shows high salinity contents .

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(Fig.1) Key map of the study area and locations of the investigated wells.

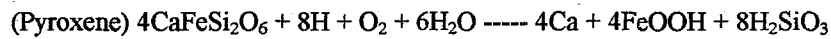
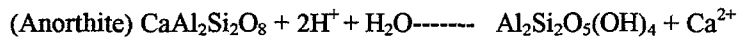
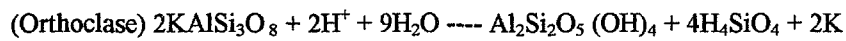
The application of the hydrochemical model named wateqp on some selected water samples showed that, groundwater in the southern and middle parts is supersaturated with calcite, dolomite, kaolinite, siderite, rhodochrosite and silica minerals which reflect hydrolysis of feldspars, amphiboles, biotite and pyroxenes. In the northern part, groundwater is supersaturated with gypsum, gibbsite and sepiolite which reflect dissolution and ion exchange processes of marine facies and sulphate bearing deposits.

Introduction

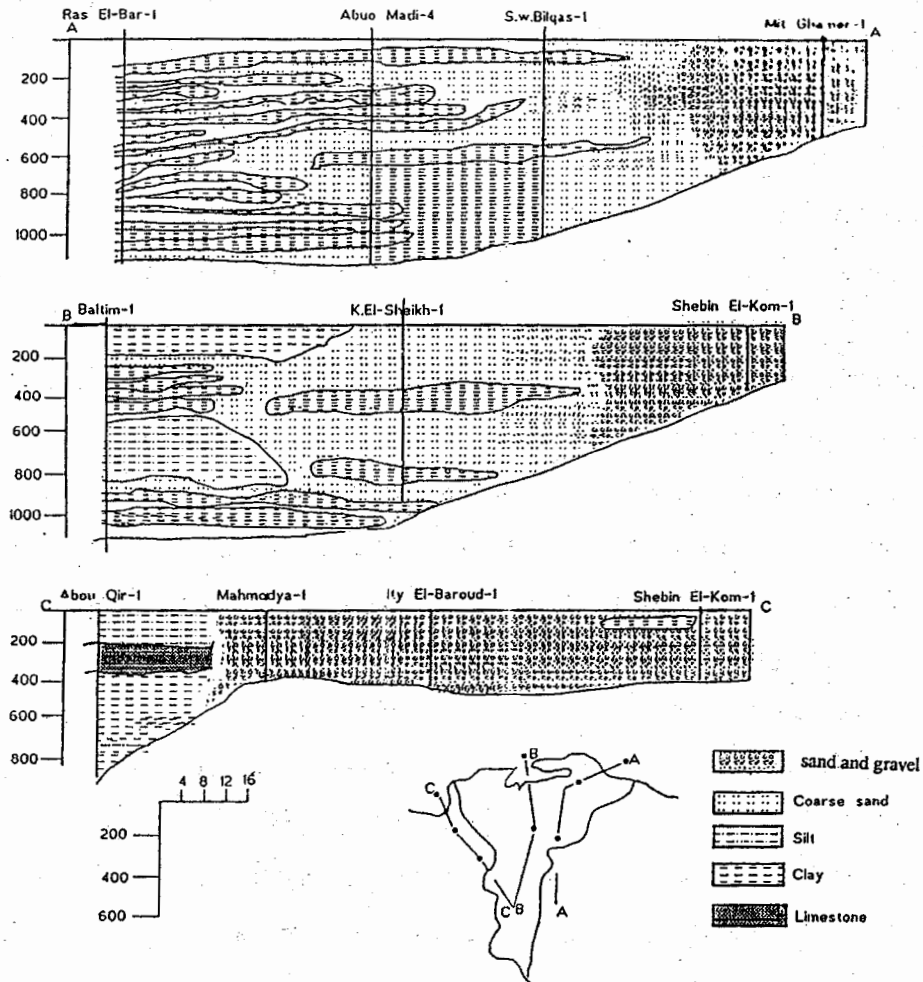
The Nile Delta contains one of the biggest groundwater reservoirs in Egypt, it is considered the main water source of irrigation, industrial and domestic purposes. The Nile Delta area (Fig.1) represents a great morphotectonic depression (Ball, 1939). In the southern and middle parts, this depression was filled with fluvial facies derived from weathering of silicate minerals particularly feldspars, amphiboles, pyroxenes and metamorphic minerals. The thickness of these facies ranges from 200 m to 600 m (Fig.2). These Facies were exposed to successive leaching and dilution processes by the fresh Nile water and the infiltrated heavy rainfall which prevailed during Early and Middle Pleistocene times. The groundwater encountered in these deposits is often rich in Ca^{2+} , Mg^{2+} , Fe^{2+} , Mn^{2+} and dissolved silica as a result of the hydrolysis process of silicate minerals. Geochemical reactions explaining hydrolysis processes of

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such minerals are presented her below in equations (1-5) (Sticher and Bach, 1966).



In the northern part, the Nile Delta depression was filled with fluvio- marine and marine facies with thickness ranging from 700 m to more than 900 m (Fig.2). The presence of these deposits with thickness ranging from 700 to more than 900 m (Fig.2). The presence of these deposits with huge thickness reflect successive Sea invasion during Late Pleistocene and Holocene times. The groundwater taped in these deposits shows high salinity contents, low contents of less soluble Ca (HCO₃)₂ and Mg(HCO₃)₂ and high content Nacl of CaSO₄, MgSO₄. The high contents of these salts reflects dissolution of marine facies such as gypsum and evaporites. This mechanism causes a rise in the Ca²⁺ ion content and consequently a fall in the concentration of HCO₃ and CO₃ ions by precipitation of calcium carbonate, thus water



(Fig.2) Geological cross sections showing the change in the lithological characteristics of the Quaternary aquifer from south to north (Serage El- Din,1989).

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ultimately become saturated with CaSO_4 . The presence of more soluble salts in the deposits such as Na_2SO_4 or MgSO_4 , causes a rise in SO_4 and consequently a fall in the concentration of Ca^{2+} by precipitation of CaSO_4 . Therefore, groundwater shows high content of MgSO_4 . The presence of the highly soluble sodium chloride salt in sediments causes a rise in Na ion and consequently a fall in SO_4 by the precipitation of MgSO_4 and Na_2SO_4 , therefore the groundwater shows high content of NaCl and MgCl_2 and MgSO_4 in the northern part (Schoeller, 1962). Ion exchange is also common process in groundwater of the Nile Delta due to the wide distribution of exchangers and due to the ions involved. One simple proof of this is the occurrence of waters in which the sum of the equivalent weights ($\text{Ca}^{2+} + \text{Mg}^{2+}$) is less than the HCO_3 ion concentration. In this case one must assume that the excess of HCO_3 ions relate to alkali ions and that of the original Ca^{2+} concentration equivalent to HCO_3 content was diminished by exchange of Ca^{2+} to combine with Na^{1+} ions giving $\text{Na}(\text{HCO}_3)$ water, this water type is widely distributed as Na- SO_4 water (Schoeller, 1962). The presence of Na_2SO_4 salt in the deep percolated meteoric water in the south and middle parts of the Nile Delta area recognizes this fact. In the northern part, this process is particularly effective where impregnation with Na-Cl-rich water occurs particularly with seawater invasion and there is widespread evidence for Na^{1+} ion exchange in these circumstances, this process occurs in the transition zone between saltwater and fresh water in the

coastal area of the Nile Delta. This process is associated with a rise in Ca^{2+} content in water and consequently the formation of Ca-Cl waters. Therefore, groundwater in the northern part contains CaCl_2 salt besides the common NaCl , MgCl_2 , MgSO_4 and CaSO_4 salts.

Hydrogeologic setting.

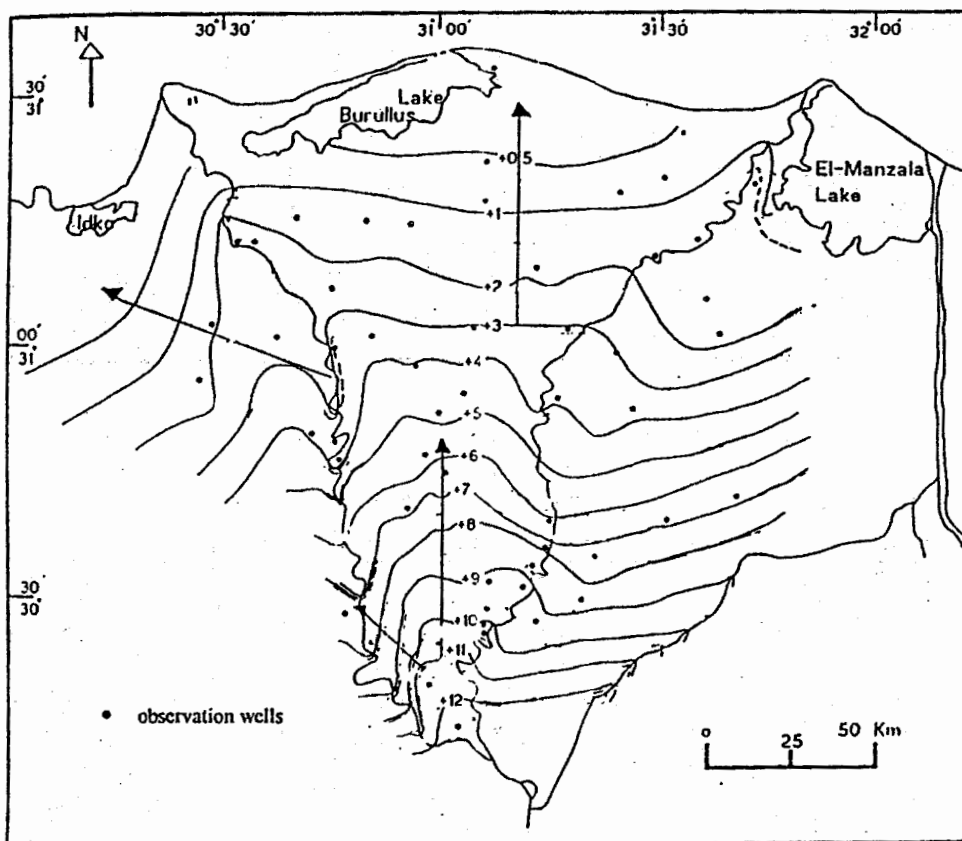
The Quaternary aquifer system in the Nile Delta comprises different lithological facies. In the southern and middle parts, the aquifer consists mainly of fluvial facies derived from weathering process of silicate minerals, which are mainly composed of quartz, orthoclase, plagioclase, mica, amphiboles, pyroxenes, metamorphic minerals and clay minerals. These sediments are in sand and gravel sizes with occasional thin silt and clay intercalations (Fig. 2). The frequency of sand and gravel reflects distributary mouth bar deposits and the presence of thin bed of silt and clay reflects variation in turbulence at the river mouth and different processes between low river stage and high river stage. In the northern part, fluvio-marine and marine clay, evaporites and limestone becomes dominant with occasional intercalations of sand and gravel (Fig.2). The occurrence of huge thickness of clay in the northern part reflects sea transgression cyclicality during Late Pleistocene and Holocene times. The thickness of the aquifer increases from south to the north and north east, where it ranges between 100-400 m in the southern part and 500-600 m in the middle part. In the northern part, the thickness of the sediments reaches their maximum value over 900 m (Fig.2). The hydrologic

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flow pattern of the Nile Delta aquifer represents one of the important factors affecting groundwater quality. The flow pattern was strongly affected by the Nile river stages and changes in sea water levels (Sestini, 1989) . In general, the southern and middle parts of the Nile Delta were subjected to successive fresh Nile water invasion especially during Early and Middle Pleistocene times, the groundwater taped in these parts was exposed to excessive leaching and dilution, it shows low salinity contents. On the other hand, the northern part was strongly subjected to excessive sea water invasion with less fresh Nile water leaching especially during Late Pleistocene and Holocene times, groundwater shows high salinity content. In the present time especially after the construction of Aswan High Dam, the groundwater flow pattern has been different, The Nile and its branches became act as effluent streams, Accordingly the leaching and dissolution processes became limited and depend only on the irrigation network. The general groundwater flow is from the south to the north towards the Sea and Coastal lakes (Fig.3). However, local groundwater flow towards the Nile branches is also shown. The piezometric head ranges from (+13 m) north Cairo city to +0.5 m at the southern border of the coastal lakes in the north.

Hydrochemical aspects

Twenty three groundwater samples in addition to two surface water samples representing Sea water and the Nile water were collected from the study area and analyzed for major and trace



(Fig. 3) Map showing the flow pattern of the Quaternary aquifer system in the Nile Delta Egypt.

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(Table.1) Results of chemical analysis of sea water , Nile water and groundwater samples

Well No.	Locality	Depth	PH	Ec (u mhos)	TDS (ppm)	Cations				Anions		
						Ca	Mg	Na	K	HCO3	SO4	CL
Sea water	-	-	7.2	59523	38156	512	141	11800	220	3250	3250	20800
Nilewater	-	-	8.1	520	330	35.4	17.28	37.33	4.17	195.2	23.5	40
1	D/S-1	75	7.6	928	598	46	30	83	7.1	195	61	105
2	D/S-2	80	8.2	775	496	50	27	38	5.2	201	60	70
3	D/S-3	95	8.7	892	572	55	35	62	6	244	70	100
4	S/D-1	90	8.3	1074	668	61	31	81	8.7	250	65	130
5	S/D-5	100	7.8	496	318	18.2	11.6	52.9	1.3	191.6	20.6	15.2
6	D/S-6	100	8.7	586	376	17.4	16.5	62.1	3.9	230.7	12.5	35.1
7	D/S-7	100	8.6	599	362	13.6	9.6	73.6	3.13	213.6	12	23.7
8	D/S-8	100	8.6	684	439	7.8	9.9	85.1	21.5	259.9	21.1	26.9
9	D/M-1	23	8.1	3382	2168	130	75.1	512	10	230	725	779
10	D/M-2	100	7.3	1740	1016	32.1	14.5	277.8	0.8	170	366	146.1
11	D/S-3	100	8.1	1232	790	42.1	14.5	127.5	3.5	140.4	240.5	135.1
12	D/M-4	100	8.4	1335	856	8.1	27.9	230	0.8	164.8	255.2	82.3
13	D/M-5	100	8.4	1684	1080	10.2	24.4	220	0.8	207	345	53
14	D/M-6	100	7	1640	1018	52.16	41.83	179.3	9.3	205	245.9	251.7
15	D/N-1	100	7.3	7430	4644	232	95	1117	8.6	205	994	1868
16	D/N-2	100	7.3	3550	2251	105	67	574	3.9	167	551	667
17	D/N-3	105	7.7	11150	7355	566	330	1671	12.2	24	595	4151
18	D/N-4	105	7.6	6312	4051	183	105	1192	7.3	91.5	199	2261
19	D/N-5	38	7.5	103000	77681	1121	3016	21555	21.1	25.2	1430	47571
20	D/N-6	25	8.1	35681	25690	760	1080	7100	49	793	3443	6871
21	D/N-7	105	8.1	10530	6774	386	196	1931	19.1	36.6	1300	23100
22	D/N-7	100	7.1	6951	4212	112	186	1081	76	106	825	1758
23	D/N-8	100	7.1	11251	8524	322	258	1200	68	92	2121	4211

(Table.2) : Results of chemical analysis of minor and trace elements in sea water, Nile water and groundwater.

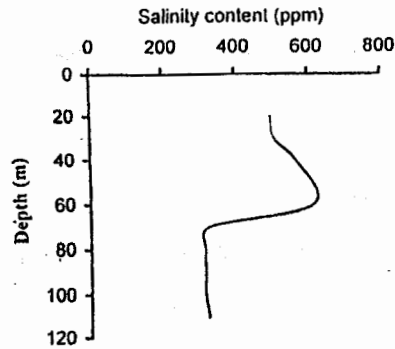
Locality	well depth	PH	TDS	Fe	Mn	SiO ₂	Cu	Cd	Ni	Zn	Hg	Br	Sr	Pb
Sea water	-	7.2	38156	0.11	0.12	3	0.01	0.001	0	0.1	0.002	76	5.4	0.05
Nile water	-	8.2	330	0.5	0.66	1	0.2	0.002	0	0.05	0.003	0.5	0.33	0.02
D/S-1	67	8.4	598	0.65	0.6	21	0.08	0.003	0	0.4	0.003	0.59	0.54	0.01
D/S-2	67	8.3	496	0.44	0.12	33	0.07	0.001	0	0.4	0.002	0.62	0.66	0.02
D/S-3	90	8.5	572	1.02	0.13	27	0.04	0.002	0	0.5	0.003	0.43	0.44	0.01
D/S-4	77	8.3	668	1.08	0.32	23	0.05	0.001	0	0.7	0.001	0.55	0.56	0.01
D/S-5	67	8.2	318	0.7	0.4	22	0.04	0.001	0	0.4	0.001	0.66	0.7	0.02
D/S-6	67	8.2	376	0.99	0.16	26	0.08	0.001	0	0.4	0.002	0.44	0.67	0.01
D/S-7	65	7.7	362	0.2	1.06	23	0.1	0.001	0	0.4	0.002	0.6	0.54	0.02
D/S-8	67	8.2	439	0.6	0.25	22	0.12	0.001	0	0.4	0.002	0.56	0.45	0.02
D/S-9	90	8.3	1016	0.22	0.32	19	0.09	0.001	0	0.1	0.002	0.77	0.38	0.01
D/S-10	90	8.5	21680	0.85	0.65	16	0.09	0.001	0	0.3	0.002	0.54	0.67	0.01
D/M-11	65	8.3	2168	1.01	0.4	17	0.09	0.002	0	0.1	0.001	0.67	0.6	0.01
D/M-12	63	8.4	1016	0.23	0.2	13	0.1	0.001	0	0.1	0.001	0.55	0.67	0.01
D/M-13	62	8.1	1018	0.34	0.25	14	0.1	0.001	0	0.1	0.001	0.55	0.67	0.01
D/M-14	63	8.4	4644	0.45	0.34	12	0.09	0.001	0	0.1	0.001	0.56	0.66	0.02
D/M-15	70	7.9	2251	0.43	0.27	11	0.06	0.001	0	0.2	0.001	2.33	1.03	0.02
D/M-16	63	8.3	7355	0.54	0.13	10	0.07	0.001	0	0.1	0.001	9.56	5.67	0.02
D/N-17	65	7.5	77681	0.12	0.23	11	0.06	0.002	0	0.2	0.002	112	7.4	0.01
D/N-18	40	7.6	77681	0.21	0.17	9	0.03	0.002	0	0.1	0.002	112	6.2	0.01
D/N-19	63	7.3	25690	0.22	0.1	8	0.04	0.001	0	0.1	0.002	11	5.05	0.01
D/N-20	105	7.6	6774	0.02	0.15	9	0.04	0.001	0	0.2	0.002	15	4.88	0.01
D/N-21	105	7.6	4212	0.09	0.14	8	0.09	0.002	0	0.3	0.001	14	5.66	0.01
D/N-22	105	7.1	4051	0.08	0.09	12	0.05	0.002	0	0.1	0.002	11	6.56	0.02
D/N-23	105	7.1	8524	0.06	0.07	9	0.07	0.001	0	0.1	0.001	11	6.56	0.02

elements (Tabels.1 and 2). Detailed description of the hydrochemical parameters will be given her under.

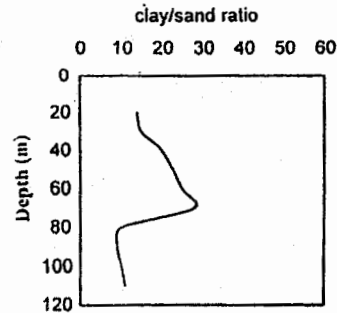
Salinity distribution :

Groundwater of the Quaternary aquifer in the Nile Delta has a wide range from very fresh water to highly saline water. In the southern and middle parts, groundwater belongs to fresh water type, salinity content ranges from less than 300 mg/l to 1000 mg/l. Salinity changes with depths were measured at some localities (Fig 4). The Change in salinity contents in these parts is mainly associated with Presence of clay ratio in the aquifer materials. Relatively high salinity content (600 and 1000 mg/l) are recorded at zones of high clay ratio ranging between 40 % and 35 %. Low salinity (200 to 400 mg/l) is recorded at zones of low clay ratio ranging between 5% and 10 % (Fig. 5). Moreover, the increase in salinity contents is usually associated with increase in calcium, magnesium and bicarbonate, which reflect hydrolysis of silicates minerals particularly calcic- plagioclase, biotite, amphiboles and pyroxines. In the northern part of the Nile Delta, groundwater quality ranges from brackish to highly saline water type, salinity contents ranges from 4000, 12000 and 70000 mg/L. , large changes in salinity contents with depth are also detected. The increase in salinity in this part is mainly attributed to the increase of lagoonal, march and swamp deposits in the aquifer materials. It is noticed that, high saline water ranging from 60000 mg/l to 120000 mg/l is detected at shallow depths between 20 and 60 m (Fig.6) where the marine

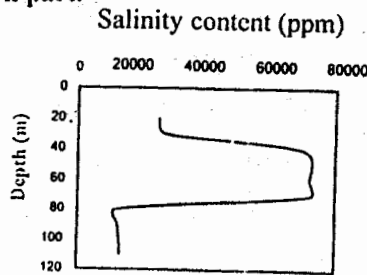
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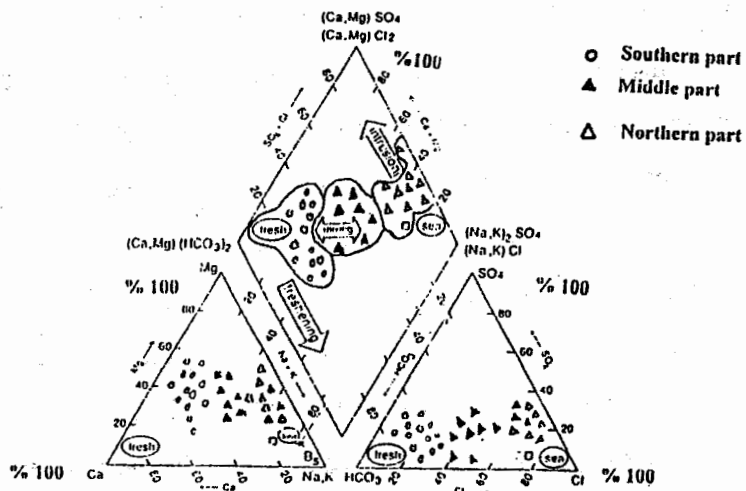
(fig.4) Salinity change with depth in the southern part.



(fig.5) Clay ratio change with depth in the southern part.



(fig.6) Salinity change with depth in the northern part.



(fig.7) Piper Diagram for presentation of the Nile fresh water, Sea water and groundwater.

facies are well developed. The increase in salinity in these zones is usually associated with increase in chloride, sulphate, sodium, magnesium and calcium which reflect dissolution processes of lagoonal, march and swamp deposits. Relatively low saline water (Brackish water) ranging between 4000 and 8000 mg/l is detected at large depths more than 100 m. This type of water represents the mixing zone between north ward fresh water flux and inherited saline water of the paleo- sea water invasion.

Ions distribution and dominance

Groundwater of the Quaternary aquifer in the Nile Delta shows a wide range of major ions. In the southern and middle parts, it is often rich in Ca^{2+} , Mg^{2+} , HCO_3 and dissolved silica. High concentration of such elements reflects the hydrolysis of silicate minerals. The bicarbonate is the most dominant anion over chloride and sulphate ($\text{HCO}_3 > \text{Cl} > \text{SO}_4$) while calcium and magnesium are the most dominant cation over sodium and potassium ($\text{Mg} + \text{Ca} > \text{Na} + \text{K}$). Hardness bicarbonate salts which include $\text{Mg}(\text{HCO}_3)_2$ and $\text{Ca}(\text{HCO}_3)_2$ are the common salts followed by NaCl and Na_2SO_4 . The presence of Na_2SO_4 in the majority of groundwater samples in these parts reflect deep percolation of groundwater solution and long term contact time between aquifer materials and groundwater. In the northern part, groundwater is often rich with Na^{1+} , Mg^{2+} , Ca^{2+} and Cl , and SO_4 . Chloride anion followed by sulphate are the most predominantly

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anions ($\text{Cl} + \text{SO}_4 > \text{HCO}_3$) and sodium followed by magnesium are the most predominantly cations ($\text{Na} + \text{k} > \text{Mg} + \text{Ca}$), the highly soluble NaCl and MgSO_4 followed by CaSO_4 and CaCl_2 are the commonest salts. It is also showed that the ground water samples collected from the northern and coastal areas show a surplus of Ca^{2+} and Mg^{2+} which indicates seawater intrusion,

Groundwater origin and genesis

With reference to figure (7), the groundwater samples collected from the southern and middle parts lie close the Nile water on the mixed line. The closeness of groundwater samples to the Nile water in Piper diagram evidence freshening occurred by the fresh Nile water invasion which prevailed during Early and Middle Pleistocene times. The groundwater of this group is described as normal alkaline earth bicarbonate water type. Groundwater samples collected from the Middle part lie in between fresh and seawater composition in the Piper diagram, this group is a transition type between the fresh water in the south and saline water in the north. In the northern part , the groundwater samples lie above the sea water end member on the mixed line which reflect sea water invasion. High Calcium and magnesium concentrations in groundwater samples reflect long- term contact time of sea water intrusion which prevailed during Late Pleistocene and Early Holocene times.

Regional distribution of minor elements in the groundwater:

The regional distribution of the minor elements and their concentration in groundwater of the Nile Delta are discussed herein through the results of the chemical analysis presented in Table (2). It is found that iron, manganese and dissolved silica are the commonest minor ions in groundwater, they cause problems in groundwater uses especially in domestic uses. Iron concentration in groundwater has a wide range from 0.12 mg/l to 2.5 mg/l. The presence of iron in high concentration and regional scale especially in the southern and middle parts reveals the hydrolysis of magnetite and the nesosilicate olivine. Change in iron concentration with depth at some localities is also recorded, it shows different values with depth at the same locality (Fig.8). Moreover the study showed also that the increase in iron concentration is not associated with increase in salinity content, where the majority of groundwater samples, which show high contents of iron, have low salinity contents. The presence of manganese also in regional scale and with high concentration in groundwater solution is due to weathering processes of some pyroxenes and metamorphic minerals present in aquifer materials. Manganese concentration ranges from 0.2 and 1.3 mg/l depending mainly on the presence of manganese bearing deposits (Fig.9). The study showed also change in manganese concentration is not associated with salinity contents.

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Regional distribution of bromide and strontium shows large variation over the whole area. In the southern and middle parts, they show small content ranging between 0.66 and 0.44 mg/l close to that of the Nile water (0.33 mg/l) (Table. 2) .which indicate direct influence of the Nile water in these parts. In the northern part, Strontium and bromide elements have high concentration, bromide ranges between 12 and 14 mg/l in the deep wells and reaches more than 112 mg/l, in some shallow wells. Strontium ranges between 7.4 and 4.88 close to the sea value (5.4). High content of these elements reflects the influence of marine facies and sea water invasion in the northern part.

The rest of minor elements such as lead, Copper, Zinc, Cadmium, Mercury, Silver and Arsenic are very rare in groundwater solution and their concentrations in groundwater solution are very small, they range from 0.01 to 0.001 mg/l and they cause no problem in groundwater uses.

Mineral contents and their saturation states

Mineral contents and their saturation states in groundwater solution of the Nile Delta are determined by applying hydrochemical model named WATEQ, this program is designed by Truesdell and Jones (1973), it is now available in many versions. A pascal version 2 of WATEQ, named WATEQP, which is designed for use on PCs is available in this work. WATEQP calculates the equilibrium

distribution of species in an aqueous solution and the state of saturation for relevant minerals. The program consists of three files internally documented named WATEQP. ELE, WATEQP SPE, and WATEQP. MIN. which contain respectively elements, species and mineral thermodynamic data. To estimate the previous parameters, activity coefficients and chemical activity of elements in solution are introduced, the activity coefficient was calculated by applying Davies equation (1962) as following:

$$\log Y_i = Az_i^2 \left(\frac{I}{1+I} \right) - 0.31$$

where A is the temperature, z_i is the charge of ion and I is the ionic strength which describe the number of electrical charges that, are present in solution. The ionic strength is defined by the following equation :

$$I = \sum \frac{1}{2} m_i z_i^2$$

where $m_i = \text{mol/l}$ and z_i is the charge of ions as mentioned before

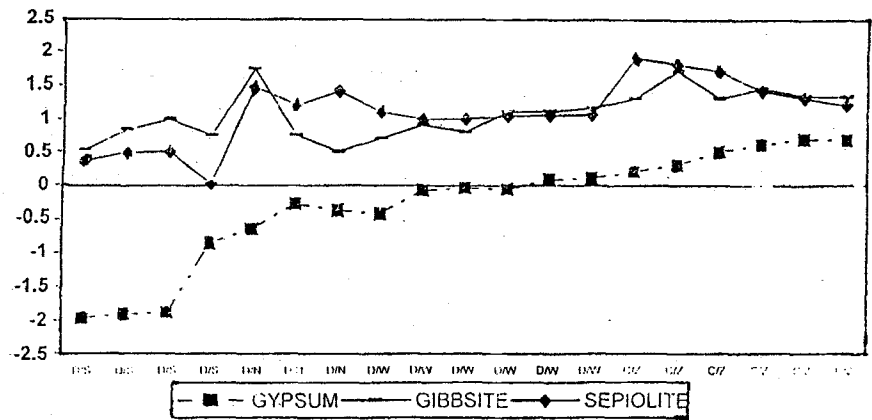
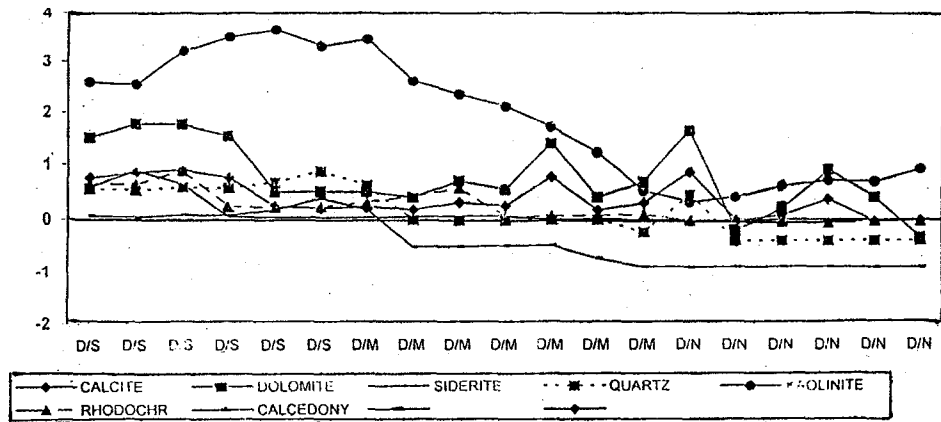
Ion activity product of any element is the product of activity coefficient multiplied by concentration of element in mol/l as following :

$$IAP = m_i \times Y_i$$

The state of sturation of groundwater solution for any mineral can be also obtained, It expressed as the ratio between ion activity product (IAP) and solubility product (K) as following :

$$\Omega = IAP/K$$

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(Fig. 10, A,B) Shows change in in saturation indices of some minerals from south to the north of the Nile Delta

Thus for $\Omega = 1$ the solution is at equilibrium, $\Omega > 1$ supersaturation and $\Omega < 1$ subsaturation. For larger deviations from equilibrium, a logarithmic scale can be useful which termed as the saturation index SI:

$$SI = \text{Log} (IAP/K)$$

For $SI=0$, there is equilibrium between the mineral and the solution, for $SI < 0$ is subsaturation and there is dissolution of mineral in solution and for $SI > 0$ is supersaturation and there is precipitation of mineral from solution

The above mentioned model was applied on some selected groundwater samples representing the Nile Delta. The obtained results of saturation indices (SI) of relevant minerals and type of geochemical processes occurring in groundwater solution have been presented in Table (3) and figure (9 A, B). It is found that, groundwater solution in the Nile Delta has a wide range of minerals which include, kaolinite, calcite, dolomite gypsum, gibbsite, siderite, rhodochrosite, quartz, chalcedony and sepiolite minerals. Some minerals such as Kaolinite, calcite, dolomite, Siderite, Rhodochrosite and dissolved silica show supersaturated states and high positive values of saturation indices (SI) in the southern and middle parts of the study area, it ranges from 0.8 to 3.57. Supersaturation states of these minerals in such localities reflect weathering processes of silicate minerals such as feldspars, amphiboles and pyroxenes and tendency of such minerals to precipitate from solution. Some others

(Table 3) Results of Saturation indices of the relevant minerals in groundwater of the Nile Delta

SI	CALCITE	DOLOMITE	SIDERITE	QUARTZ	KOLINITE	RHODOC	CALCEDONY	SEPIOLIT	GYPSUM	GIBBSIT
D/S	0.75	1.51	0.58	0.55	2.58	0.64	0.06	0.37	-1.96	0.53
D/S	0.85	1.77	0.88	0.53	2.53	0.63	0.04	0.49	-1.9	0.83
D/S	0.89	1.76	0.63	0.57	3.21	0.87	0.08	0.5	-1.87	0.98
D/S	0.75	1.54	0.04	0.56	3.49	0.23	0.07	0.02	-0.87	0.75
D/S	0.23	0.49	0.03	0.66	3.64	0.21	0.17	1.47	-0.66	1.73
D/S	0.19	0.49	0.02	0.86	3.3	0.22	0.37	1.2	-0.3	0.75
D/M	0.22	0.48	0.02	0.6	3.44	0.3	0.17	1.4	-0.4	0.5
D/M	0.16	0.38	0.03	-0.03	2.59	0.4	-0.53	1.1	-0.45	0.7
D/M	0.29	0.68	0.04	-0.04	2.33	0.55	-0.53	0.99	-0.09	0.9
D/M	0.23	0.52	0.04	-0.04	2.1	0.03	-0.51	0.99	-0.05	0.8
D/M	0.75	1.38	-0.03	-0.03	1.7	0.04	-0.5	1.03	-0.07	1.1
D/M	0.15	0.38	-0.02	-0.03	1.2	0.05	-0.75	1.04	0.07	1.1
D/M	0.28	0.66	-0.03	-0.26	0.5	0.07	-0.92	1.05	0.1	1.15
D/N	0.84	1.63	-0.04	0.43	0.3	-0.05	-0.92	1.9	0.2	1.3
D/N	-0.03	-0.23	-0.05	-0.42	0.4	-0.09	-0.91	1.8	0.3	1.7
D/N	0.06	0.19	-0.02	-0.42	0.6	-0.07	-0.91	1.7	0.5	1.3
D/N	0.35	0.88	-0.02	-0.42	0.7	-0.09	-0.91	1.4	0.6	1.44
D/N	-0.06	0.39	-0.03	-0.42	0.67	-0.05	-0.92	1.3	0.68	1.33
D/N	-0.04	-0.36	-0.02	-0.42	0.6	-0.06	-0.92	1.2	0.67	1.32

SI = Saturation index D / S : South Delta D / M : Middle Delta D / N : North Delta

such as gypsum, gibbsite and sepiolite show appreciable increase in saturation indices in the northern part than the southern and middle parts which reflect dissolution and ion exchange processes of fluviomarine and marine facies. In general, wide range of minerals and supersaturated states of the majority of them in the groundwater solution reflect different sources of aquifer materials and long contact time between aquifer materials and groundwater .

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تأثير نظام السريان المائى ومكونات الخزان على نوعية المياه
والمحتوى المعدنى (حالة دراسية - دلتا النيل - مصر)

كمال ذهب

قسم الجيولوجيا - علوم الموفية

يناقش البحث العوامل المختلفة التى أثرت على نوعية المياه خاصة تلك التى تتعرض للنواحي الهيدروجيولوجية والليثولوجية للخزان الجوفى التى أثرت على الملوحة ونسب العناصر الكيميائية كما أستعرض البحث العمليات الكيميائية السائدة التى كان لها دور كبير فى تحديد التركيب الكيميائى والمعدنى وأهتم البحث أيضا بدراسة العناصر النادرة فى المياه حيث لها مدلول جيد فى تحديد طبيعة الظروف الهيدروجيولوجية السائدة أثناء تكوين المياه .

قد أظهرت نتائج الدراسة أن الأجزاء الجنوبية و الوسطى من الدلتا مكونة من رواسب نهريّة تحتوى على معادن السليكات والمثلة بالكوارتز والفلسبار و البيروكسينات والأمفيبولات ، ان المياه تأثرت بمياه النيل خلال زمن البليستوسين المبكر و المتوسط و المياه الجوفية فى هذه الأجزاء عزبة وصالحة للأستخدام فى الأغراض المختلفة و غنية بعناصر الكالسيوم و الماغنسيوم و البيكربونات و الحديد و المنجنيز والسليكا. كما تبين أيضا أن

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المياه فى هذه الأجزاء مشبعة بمعادن الكالسيت و الدولوميت و الكاوليتيت والسليكا.

كما أظهرت الدراسة أن الجزء الشمالى من دلتا النيل مكون من رواسب بحرية ممثلة بالطين و المتبخرات مع تدخلات من الرمل و المياه تأثرت بمياه البحر خلال عصر البليستوسين المتأخر والهولوسين و المياه فى هذا الجزء تتراوح من مياه متوسطة الملوحة فى الأعماق الكبيرة الى مياه عالية الملوحة فى الأعماق الضحلة و المياه غير صالحة للأستخدام فى الأغراض المختلفة و أنها غنية بالصوديوم الماغنسيوم و الكلوريدات و الكبريتات كما أنها مشبعة بمعادن