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Use of Vertical Electrical Monitoring Technique to Explore Groundwater

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ABSTRACT

For exploration groundwater in wide area of Wadi El-Natrun, the vertical electrical sounding techniques (VES) was installed and deduced for 43geoelectric profiles. Data were collected around 20 wells to determine the hydraulic parameters of soil layers from 1.5 to 18 m as maximum depth. The measuredparameters included the electrical resistance of the different layers as well as measurement of the thickness and depth of the layers, in additions the relationship between the resistance and saturation percentage, and also the relationship between hydraulic conductivity and electrical resistance.The interpretation of resistivity data, referred to the resistivity of this soil, ranged between 2Ω.m and982.5Ω.m.These VES were interpreted to determine the subsurface layers and the true resistivity's, lithology's and thicknesses variations of such layers. The result of this geoelectrical analysis is the subdivision of the shallow section into five geoelectric layers throughout the study area, except in some parts, where the surface layer disappeared; and the fifth layer is not reached. These layers varied in their resistivity's from very low to high values. However, the groundwater is generally contained in the second layer of the unconfined Nile Delta aquifer (Quaternary period), in the third and fourth layers of the confined and semi-confined Wadi El-Natrun aquifer (Pliocene period), then in the fifth layer of the Moghra aquifer (Lower Miocene period). The well log data of the resistivity, SP and gamma-ray logs were used for evaluating the rock units encountered in 20 wells. Then, the statistical analysis from the true resistivity that derived from the geoelectric analysis, and water saturation that deduced from the well log analysis, was carried out, only to the third layer. The results of these calculations showed that, the third layer as high groundwater content, then the fourth layer, but the second layer contains the least amounts. Therefore, the electrical resistivity measurements can be used for estimating the groundwater amounts in case of availability the geological information and the well log data are not available . It may be concluded from the present study : Exploration of ground water in Wadi El-Natrun using the VES sound electric instrument.Collected data of 20 wells for 5 years and VES readings data were analysed fordifferent thickness and layers from 0 up to 18 m, to obtain the relationship between the storativity, layer saturation percentage on hydraulic conductivity and transmissivity.

Keywords: DC Resistivity; resistivity Values; Physical properties of soil; unsaturated hydraulic conductivity; irrigation type; drainage canal; Wadi El-Natrun Area; Egypt.

INTRODUCTION

Nowadays, great attention is paid by the Egyptian authorities for the establishment of new settlements and land reclamation projects to overcome the over population problem. In this respect, the southwestern fringes of the Nile Delta constitute a promising area for land reclamation due to its favorable soil, availability of groundwater and accessibility to Cairo, Alexandria, Central Delta and the northwestern coast. The area under consideration attracts the attention of several investements in the field of land reclamation especially after the construction of Wadi El Natrun – Alamein road that cross the northwestern portion of the study area. In this area several water wells were drilled for groundwater exploration and exploitation for the construction farms. Accordingly, it is recently subjected to intensive studies in the field of geology, pedology and hydrology.

West Nile Delta area attract the attention of many authors since 1902. The available studies are dealt with the geomorphology, geology, hydrogeology, hydrology and hydrogeochemistry. Among workers of geomorphology, the following are of great importance; Shata (1947) cleard that the sand accumulations in the NW-SE direction at El Henishat area must be underlain by topographical and/or tectonical features of the same orientation. Shata (1962) classified the area between Cairo and Wadi El-Natrun into six geomorphologic units. These units are; the gravel terraces of the Nile, the old gravel plains, the tableland area, Wadi El Natrun and Wadi El-Farigh depressions and upland area. Shata and El Fayoumy (1967), Abu Al-Izz, (1971), Attia (1975), and El Ghazawi (1982) classified west Nile Delta area into six geomorphic units. These units are; the coastal plain, the northern table land, alluvial plains, structural plains, the Southern tableland and shifting sands.

In view of the regional geology, the study area is roofed by extensive exposures of sedimentary successions ranging in age from Late Cretaceous to Quaternary. The oldest sedimentary rocks in the area are represented by Late Cretaceous rocks, which have a localized occurrence on the crest of a complicated folded structure of Abu Roach anticline, whether Eocene and Oligocene sediments are of a limited distribution in the environ of Cairo. The younger rocks of Miocene, Pliocene, and Quaternary times are the greatest projection sediments dominating the studied area. Middle Tertiary basalt sheets are the only exposed volcanic rock in the area, particularly in the southeastern portion. The present study of the investigated area dealt with detailed description of Lithostratigraphy, grain Size analysis, mineralogical study geologic structure, and geologic history El Ghazawi (1982).

The surface exposures and the subsurface successions in the investigated area was clarified from oil deep wells and recent water wells, as well as from the geophysical studies. The strata of hydrogeological interest are related to the Late Tertiary and Quaternary deposits. They act as important water-bearing formations and consequently, they intensively taken into consideration. The stratigraphic succession reported in the study area from base to top includes the following rock units Sanad (1973).Triassic rocks are encountered at Wadi El Natrun test well No.1 at 3795 m depth. These rocks are composed mainly of shale and limestone intercalations with a thickness of about 274 m.Said (1962).Jurassic rocks are encountered at a depth of 2645 m and 438 at Wadi El Natrun test well No.1 and El Khatatba test well No.1 attaining a thickness of 1500 and 1435 m respectively. These rocks are composed mainly of limestone and shale with sandstone lenses.Cretaceous rocks are encountered in Wadi El Natrun test well No.1 and El Khatatba test well

No.1 with a thickness of 1400 m and 191 m respectively. These rocks are overlain by Oligocene deposits at El-Khatatba test well No.1 while they are overlain by Eocene deposits at Wadi El-Natrun test well No.1.

To achieve this goal, the following hydraulic factors were estimated and studied: the measured parameters included the electrical resistance of the different layers as well as measurement of the thickness and depth of the layers, in additions the relationship between the resistance and saturation percentage, and also the relationship between hydraulic conductivity and electrical resistance.

MATERIALS AND METHODS

Study area (Wadi El Natrun)

The study area lies at El-Behera governorate, Western of Nile Delta, Egypt between Longitudes 30° 00' and 30° 33' E and Latitude 30° 20' and 30° 30' N. It parallels to (Cairo-Alex. Desert Highway) km 90 to km 110. The study area covers about 2016 Km2(Fig.1). The study area comprises a total area of about 770 km2. From the hydrological cross section, which pass through Wadi El Natrun area in West-East direction. Pliocene aquifer and from electrical sounding,(VES) this aquifer unit is mainly formed of alternating sand and clay and occasionally capped by thin layer of limestone. The Pliocene aquifer is considered as multi-layers' aquifer under confined to semi confined condition. Most of these waters bearing layers belong to the upper and middle Pliocene. In this study, the information of 111 pumping wells and 14 observation wells were collected as well as other parameters such as hydraulic conductivity.

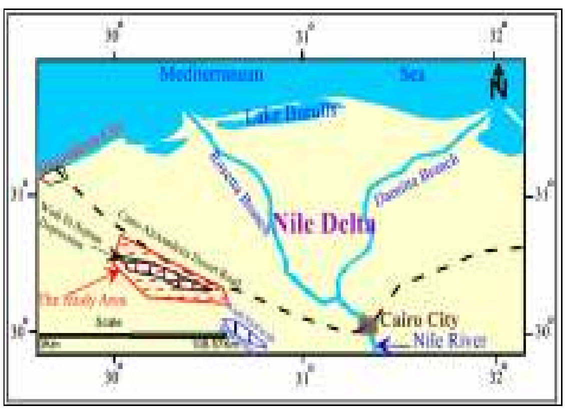

Fig. 1. Location of the study area

Instruments: the electrical resistivity techniques was used tomeasure and to determine each earth electrical resistivity. The used (VES) meter is showin (Fig. 2).

It conceded the following pants:

1- The SYSCAL utilizes external DC current for energizing the ground (800 V max. output voltage).
2- 250 W DC/ DC converter obtianed via 12V battery.
3- 1200 W AC/DC converter supplied by a standard motor generator.

Field Measurements:

The main measured property from this study at the field is the apparent resistivity (p_a). Where the apparent resistivity, in (Ω.m), at the center of a Schlumberger array was calculated from this equation:-

$$p_a = \frac{\pi r^2}{a}\frac{V}{I} \quad \ldots\ldots(1)$$

where:

I is the current, V is the potential and r or a are distances between different electrodes.

Fig. 2. the IRIS device used measuring resistivity

For accurate results, (a) should be less than one - fifth of (r) (Dobrin,et al. 1980). Then, for studying or measuring the apparent resistivity of the very shallow depths as reported at this study or to depths up to 5m (the interested depth in agriculture activities), the distance between the potential electrodes must be constant but the distance between current electrodes must be changed or increased.

By Schlumberger array, forty-three Vertical Electrical Soundings (VES) were carried out in the area of study for measuring the apparent resistivity of the surface and subsurface geological layers (Fig. 3) to identify the lithology (texture) of the surface and subsurface sediments and to delineate the water-bearing layers across the area depending on the water content into the pores of these sediments.

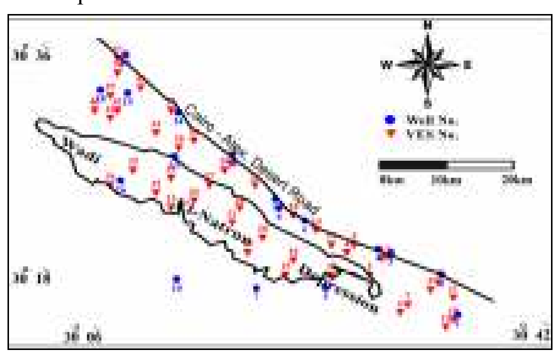

Fig. 3. Vertical electrical soundings (VESes) and Wells locationsdistribution map of the study area.

Generally, the measured injected current (I) and potential difference (ΔV) were converted to an apparent resistivity (pa) by using the following law (Ohm's law):

$$p_a = L\,\frac{\Delta V}{I} = LR \quad \ldots\ldots(2)$$

where:

L is the geometrical factor (meter) of the electrode configuration.
R is the measured resistance.

The geometrical factor (L) was determined by the following equation:

$$L = \frac{\pi}{P_1P_2}\left[\left(\frac{C_1C_2}{2}\right)^2 \ldots \left(\frac{C_{1n}C_{2n}}{2}\right)^2 \ldots \left(\frac{P_1P_2}{2}\right)^2\right] \quad \ldots\ldots(3)$$

where:

C_1C_2 is the distance in meter between C_1&C_2.
P_1P_2 is the distance in meter between P_1&P_2

Calculating the groundwater potential from the well logging and geoelectric investigation : From comparison between obtained total effective (T_{AV}) and net (T_{NAV}) thickness values from the well logging and geoelectric analyses, the following findings in table (1) applied for estimating the ground water potential.

Table 1. Comparison between the calculated total effective and net thickness values estimated from the well logging and geoelectric analyses.

geoelectriclayers	T_{AV} (m) (from well Logging analysis)	T_{AV} (m) (from geoelectric analysis)	T_{NAV}% (from well Logging analysis)	T_{NAV} % (from geoelectric analysis)
2nd Layer	18.65	19.12	0.416	0.466
3rd Layer	111.3	107.23	0.561	0.660
4th Layer	71.7	88	0.54	0.83

As shown earlier, approximating the ground water potential of estimated layers necessitates construction of WS map to estimate Sr, net TM to conclude wideness variations and effective TM to determine the effective wideness variations of clastic zones, that are saturated with water.

These will be achieved for 2nd , 3rd and 4th geoelectric layers at examined area. to approximation ground water volume (V_w), the following formulas were utilized for computing ground water quantities as follow:

$$S_r = \frac{V_W}{P_v} \quad \text{..............................(4)}$$

$$\text{and } \eta_T = \frac{P_v}{T_v} \quad \text{...................(5)}$$

where:

S_r = the water saturation percentage of the layer.

V_w is the volume (amount) of water.

P_v is the volume of all the empty spaces (occupied by water).

T_v is the total volume of the rock.

η_T is the total porosity; consists of all the void spaces(pores, channels, fissures and vugs) between the solid components.

from equations (4) & (5): *Then*;

$$P_v = \frac{V_W}{S_r} \quad \text{.............................. (6)}$$

$$\text{and} \quad P_v = \eta_T * T_v \quad \text{.. (7)}$$

also, from equations (6) & (7):

when $P_v = P_v$

$$\frac{V_W}{S_r} = \eta_T * T_v \quad \text{........................ (8)}$$

$$\text{Then} \quad V_W = \eta_T\% * T_v * S_r\% \quad \text{................(9)}$$

$$Tv = L * W * T_{av} \quad \text{.............................(10)}$$

$$\text{and} \quad V_E = T_v * T_{NAV}\% \quad \text{................(11)}$$

Therefore, based on the above mentioned equations, the present author modified and illustrated how to derive an equation relating η_T%, (T_v, T_{NAV}%) or V_E, Sr%, is applied regionally for estimate volume (quantity) of water (V_w) in locate as exposed as follow:

$$V_W = \eta_T\% * Tv * T_{NAV} * S_r\% \quad \text{...........(12)}$$

$$\text{Or} \quad V_W = \eta_T\% * V_E * S_r\% \quad \text{............................(13)}$$

where:

T_v= total volume of the average thickness of the assessed layer,

L= length of the evaluated layer along the area,

W= width of the evaluated layer across the area,

T_{av}= average thickness of the EZs of assessed layer,

V_E= effective thickness volume of the layer,

T_{Nav}%= net thickness average of the EZs of layer,

η_T% = the porosity of lithology of the layer,

S_r% = the water saturation percentage of the layer.

Assessing ground water volume of 2nd geoelectric layer: By applying the last equations (12 - 15) and substituting, input values of this layer (Table 2), **where:** L = 9.0 cm. W = 2.O cm. S_{wav} = O.373%,

Scale factor = $\left(\frac{1000}{1.45}\right)^2 = 47562426\ m^2$

Estimating the groundwater volume(GWV) of 3rd geoelectric layer:From the application of equations (12th - 15th) and substituting in put values of this layer (Table 4.3), as : L =9.5cm, W = 2.7cm, S_{wav}=O.393%, Scale fact.= 47562426 m^2.

Estimating GWV of 4th geoelectric layer:Similarly, from equations (12th - 15th) and substituting in put values of this layer (Table 4.4), Where: L =9.0cm, W =2.4cm, S_{wav}=O.426%, Scale factor= 47652636 m^2.

Table 2. Comparison between the estimated ground water volume of 2nd layer from the well logging and geoelectric analyses.

In put and out put parameters	T_{av} (m)	T_{Nav} %	T_v (m^3)	V_E (m^3)	V_w (m^3) When η_T =10%	V_w (m^3) When η_T =20%
From well logging analysis	18.56	0.416	1.5889655^{10}	6.6100966^{09}	2.465566^{08}	4.931132^{08}
From geoelectric analysis	19.12	0.488	1.6369084^{10}	7.9881132^{09}	2.9795662^{08}	5.9591324^{08}

Table 3. Comparison between the estimated groundwater volume of 3rd layer from the well logging and geoelectric analyses.

Input and output parameters	T_{av} (m)	T_{Nav} %	T_v (m^3)	V_E (m^3)	V_w (m^3) When η_T=10%	V_w (m^3) When η_T =20%
From well logging analysis	110.3	0.581	1.34556338^{11}	7.8181322^{10}	3.072526^{09}	6.1450519^{09}
From geoelectric analysis	107.3	0.662	1.3081805^{11}	8.6601549^{10}	3.4034409^{09}	6.8068818^{09}

Table 4. Comparison between the estimated groundwater volume of 4th layer from well logging and geoelectric analyses.

In put and out put parameters	T_{av} (m)	T_{Nav} %	T_v (m^3)	V_E (m^3)	V_w (m^3) Whenϕ =10%	V_w (m^3) Whenϕ =20%
From well logging analysis	71.1	0.52	7.0591677^{10}	3.6707672^{10}	1.5710884^{09}	3.1421767^{09}
From geoelectric analysis	87	0.63	8.5655173^{10}	5.3962759^{10}	2.3096061^{09}	4.6192121^{09}

So that, depending essentially on effective and net thickness variations of 3 water-bearing layers (2nd, 3rd and 4th geoelectric layers) and when porosity (f) is assumed to be 1O% and 2O%, it can be concluded that, GW potential of 3rd layer is more than 4th one, and extremely more than in 2nd layer for the shallow aquifer of area. Therefore, water productivity is rated by same means when drilled wells in this area.

RESULTS AND DISCUSSION

Electrical measurements and thicknesses.

By the Schlumberger array, 43 vertical-electrical soundings (VES) [with AB/2 ranged between 400–1000 m] were performed. In study area by utilizing JESSE instrument through WadiEl-Natrun project by RIGW staff at locations allowing construction of 17 geoelectric cross sections. Each cross section goese through a number of VES, added to the available wells.

Quantitative interpretation of field data.

The quantitative interpretation of the geoelectrical data achieved for includes the following:

1. Interpretation of curves of VESes by means of ZOHDY'S technique (1989) and Software of RINVERT'S (1999).
2. Construction and investigation of geoelectrical cross sections.
3. Making net and effective thickness maps of recorded geoelectric layers.

Findings of the interpretation.

Findings of quantitative interpretation of VES curves give layers number in WadiElNatrun area are between 3-5 layers. Commonly, the true resistivity values (TRVs) of these layers ranged between very low (2Ω.m) and high values (982.5Ω.m), and thicknesses are between 0.9- 197.3m . The reported lithologies of 5 layers are as follow; 1st layer involves of sands, gravels and rock fragments and missed in some parts as surface layer.2nd layer consistes of marly and shaly sand, and in some parts involve lenses of shale (Nile-Delta aquifer). 3rd layer consists of clayey and sandy gravels (WadiElNatrun aquifer) and changed to clays (Pliocene clay) at the middle part of area under study. 4th layer consists of clayey sands and gravels (WadiElNatrun aquifer) . Lastly, 5th layer consists of sandstones (Moghra aquifer). All layers were recorded and debated on theprofile (I-I`), which considered as a traverse crosssection (Fig. 4).

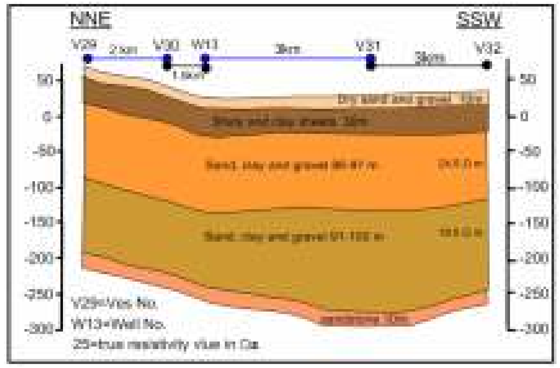

Fig. 4. Geoelectrical cross section (Ammar,A.I.,2002).

Net and effective TMs.

The net and effective TMs were made for demonstrating the lateral changes of net and EZs thicknesses thru area of assessed layers at drilling wells sites. These maps made for 2nd, 3rd and 4th layers to reveal their thickenings and thinning's of region.

Net and effective TMs of 2nd geoelectric layer: Maps in (Figs 5&6) were made to display the lateral variations of net and EZs thicknesses of 2nd layer, 3 thickening sites (A, B & C) at south-eastern and north-western parts of the area. In addition, there are two thinning sites (D and E) in the central and south-eastern parts, northwestward increase of the total net thickness of this layer was detected, indicating a comparable subsidence of basin of deposition at this direction,accordingly possibility increasing of producing ground water from the wells drilled in that direction.

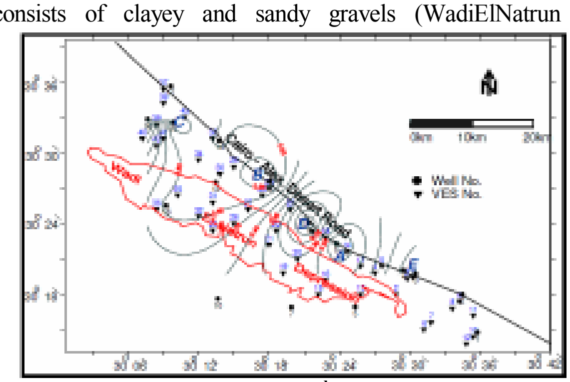

Fig .5. Fig .(4.12) : Net TM of 2nd geoelectric layer from the well logging investigation.

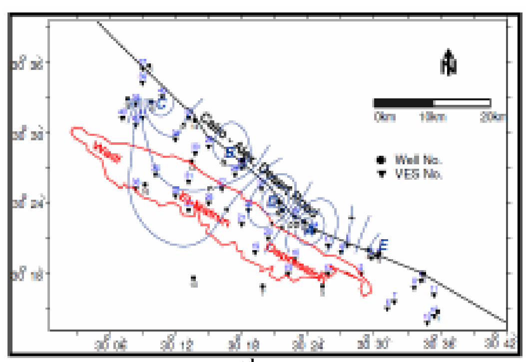

Fig.6. Effective TM of 2nd geoelectric layer from the well logging investigation

Net and effective TMs of 3rd geoelectric layer: (Figs 7&8) Maps were drawn for revealing the thinning and thickening of EZs along 3rd geoelectric layer. The thick and thin portions of are mainly similar to those of the mentioned one. Thus, the thick parts (A, B, C &D) and thin parts (E & F) occupy nearly similar locations to those of 2nd layer with an exception is in south-east ward spreading of thick part A, in a way vanishes the far south-eastern thin portion E of 2nd layer. In addition, the thin portion F is accentuated regarding the 2 surrounding thick parts (B &D), in a way configuration thick wide C of 3rd layer as comparing to 2nd layer.

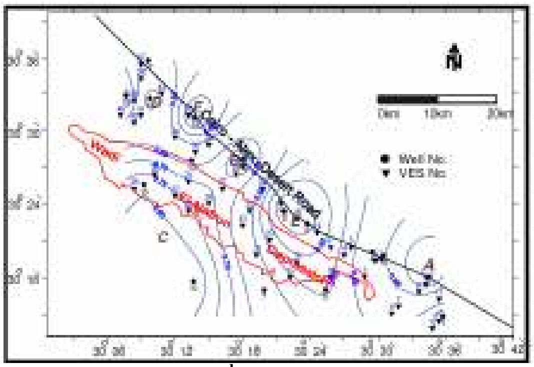

Fig. 7. Net TM of 3rd geoelectric layer from well logging investigation

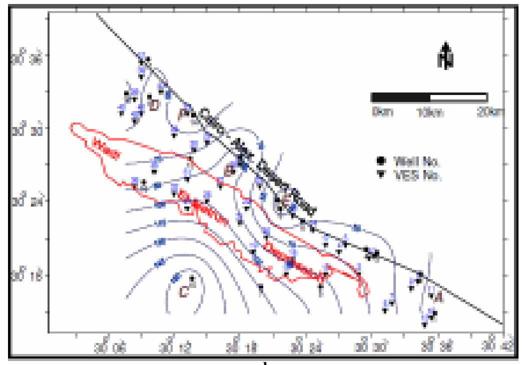

Fig. 8. Effective TM of 3rd geoelectric layer from the well logging investigation

Net and effective TM of 4th geoelectric layer: The net and effective TMs of 4th layer are displayed in(Figs 9&10), which showed 2 thin parts B & C subtending between them a thick one A. The thin parts occupy the southeastern and northwestern parts, whereas the thick one presents along central-eastern part. Therefore, entire middle part categorized by an intermediate gradient of dashed contours, because of the limitation of the penetrated electric current to whole depth range of 4th layer, in a way skips details of intermediate net thickness features of cathode and anode polarities.

In addition, there is south-east-ward elevating in net thickness of this layer in an opposite to that of 2nd layer. On the other hand, the varied net wideness topographies distribution, beside the general net thickness reversal of 4th layer, on comparing to 2nd layer added more proof of between 3rd and 4th layers separation.

True resistivity and Electrical conductivity distribution map of the soil layer.

Generally, recharge of this layer in some areas is a result of seepage from the surface water and upward leakage from deep aquifers. This layer was affected by the human activities, which use the surface water or from other means. To define the areas, which were affected by the surface water and responsible of feeding the sub-zones of the soil layer or the subsurface aquifer and the role of these factors in estimating the true physical properties, it is evident from their resistivity values (Fig. 11), that decrease with increasing the water saturation percentages or moisture content and clay content.

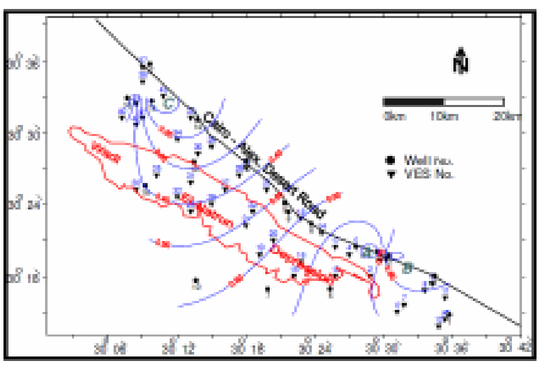

Fig.9. Net TM of 4th geoelectric layer from well logging investigation.

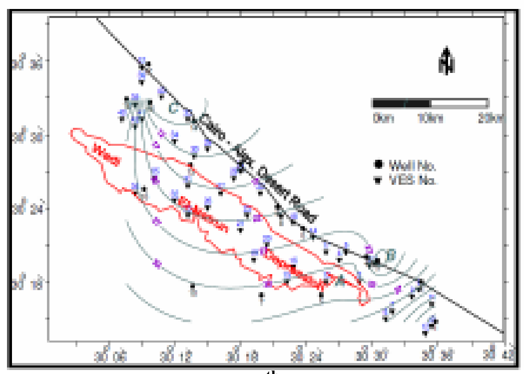

Fig. 10. Effective TM of 4th geoelectric layer fromthe well logging investigation.

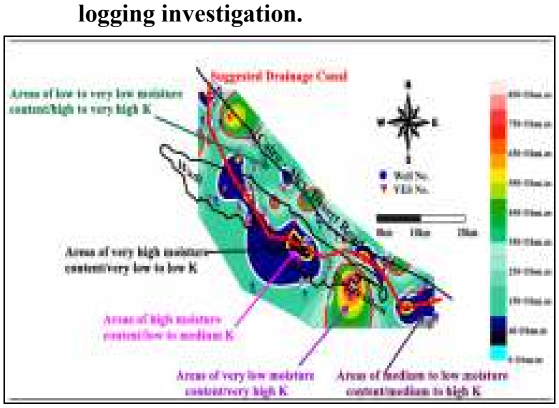

Fig. 11. True resistivity distribution map of the soil layer under investigation of the study area.

From the classification of the interpreted resistivity or conductivity values of the soil and their distribution along the area of study, as shown in (Fig 11&12), the area was distributed into five parts varying in their resistivity/conductivity values, clay contents, soil textures, porosity, moisture content and/or permeability. The major part along Wadi El-Natrun depression that was characterized by medium to low moisture content and medium to high permeability, it reflects the first degree of availability. The part of low to very low moisture content and high to very high permeability reveals the second degree. Then, the part of very low moisture content and very high permeability exhibits the third degree. But, the part of high moisture content and low to medium permeability and also the part of very high moisture content and very low to low permeability were considered the fourth and fifth degrees, respectively.

From the above conclusions, a drainage canal can be delineated, as shown on the same figures, for collecting the excess of irrigation water amounts and to minimize the water logging problem. The best places for such drainage canal were suggested at the parts that characterized with medium to low moisture content and medium to high permeability.

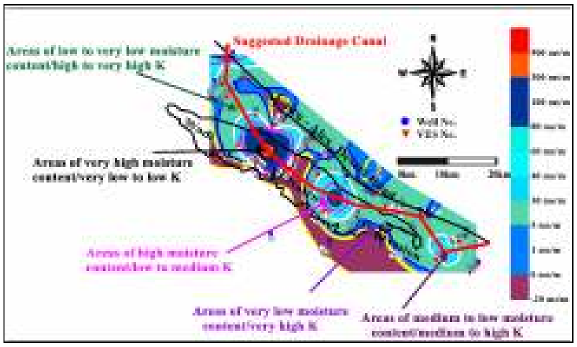

Fig. 12. Electrical Conductivity distribution map of the soil layer under investigation of the study area.

Correlation Between True Resistivity(TRV) ($P_t\Omega$.M) and (S_r%).

The deduction of a relationship between TRV and S_r% was carried out by MINITAB program, which utilized for fitting findings to best assessment of the model's parameters.statistical hypotheses were tested and the basic linear regression, (ANOVA).

The relationship between TRV and S_r% were obtained by using MINITAB statistical software, particularly for 3rd layer. Since the layer base was reached by drilling wells and electric current, and also denoted to same constituents of Wadi El-Natrun aquifer, that comprises 3rd and 4th layers.

In general, reducing TRV of rocks revealed an increasing of watersaturation into pores of these rocks (Sr µ 1/pt). the distribution is normal and identical, the general trend of the data is linear and model fit is valid. May be due to the T & F values are high, the Pvalue is declined to nil.

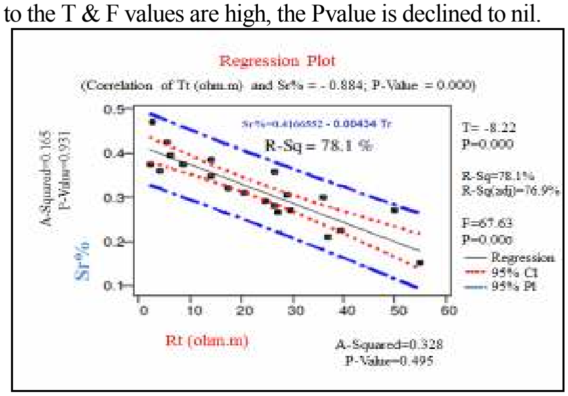

Fig. 13. The relationship between TRV and S_r% of 3rd layer (Wadi ElNatrun aquifer).

This reveals that, the evidence between 2 variables is strong and this relationship is different.The association between TRV and S_r% variables were high (-O.884; Pvalue = O.O as shown in (Fig 13). There was strong indication 0f a correlation between both and this relationship is linear ,which means that S_r% differ significantly for different pt . R2 of 2 variables is around 78.1%, that refers to pt of Wadi El Natrun aquifer/Pliocene fluviomarine aquifer system in WadiElNatrun area can not be interpreted more than 78.1 % of S_r% or around 21.9 of S_r% can not be interpreted by pt . This because of effect of shale distribution, connection and saturation of aquifer pores, also because of the influence of salinity on conductivity of water in pores. Therefore, the following linear regression used for approximating S_r% from $p_t(\Omega$.m):

$$S_r\% = 0.416652 - 0.00434\ P_t \quad \ldots\ldots\ldots\ldots(14)$$

Electrical conductivity via typical hydraulic conductivity values.

After determining the resistivity's or electrical conductivities of the recorded soils and their corresponding textures, these values are compared with the typical values of the hydraulic conductivities (K) of the same soil textures, which were compared with the available measured hydraulic conductivities. This comparison indicated that, the hydraulic conductivity values of the soil texture of this area are occurred within the typical values and summarized in (Table 5).

Table 5. The typical values of hydraulic conductivities and estimated values of resistivity's or electrical conductivities of the recorded soils.

Soil type	Av. Estimated Resistivity (ρ) in Ω. m	Av. Estimated Electrical Cond (σ=1/ρ) in $\Omega^{-1}.m^{-1}$	Av. Typical Hydraulic Cond. In m/day
Clay	0.1-5 (2)	0.5	0.0055
Sandy clay	5-10(8)	0.125	0.8
Clayey sand	10-30 (22)	0.0454	1.875
Sand	30-100(55)	0.01818	21.25

Results indicate there were a linear relationships between them (Fig.14). Theses relations indicated that the resistivity decreases with increased the clay content which attenuate the hydraulic conductivity of the associated soil and vice versa. While the hydraulic conductivity increases with decreased the electrical conductivity.

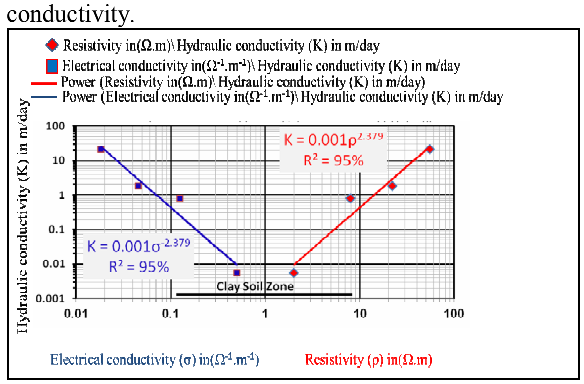

Fig. 14. The relation between Average true resistivity or electrical conductivity and typical hydraulic conductivity values of the recorded soils.

CONCLUSION

Geomorphology .

The study area having a low reliefoccupies a region of initial Nile Delta basin along its western borders. In this area, there were some geomorphic units. These units are:

1. The soil classified into alluvial plains (young allalluvial plain and old alluvial plain).
2. Structural plain occupies the area to the south and south-east of Wadi El-Natrun.
3. The regional surface Geologyarea was occupied by Late Cenozoic rocks,which dominated by clastic sediments and is rather thin.
4. The ground water in Wadi El-Natrun area sems to be confined water layers (4 to 7 layers) started at depth 38 up to 160 m depth).
5. Quaternary Period: The Quaternary period comprises Holocene age and Pleistocene age. The Holocene age was categorized by 4 rock units:-

- *The 1st rock unit* is the sand dunes and surficial deposits, where the thickness of this unit is ranging between 1Om and 3Om and the facies are mainly aeolian deposits derived from the pre-existing rocks "mainly barchans and elongated self dunes".
- The 2nd rock unit is the Sabkha deposits. The thickness of these deposits is less than 10m and the facies are fine silty deposits mixed with salt, due to the evaporation of brine salt water restricted to Wadi El-Natrun depression.
- The 3rd rock unit is the silty and sandy clay, with a thickness of +3Om and the facies are silty and sandy clay with a thin sand layer at the base "restricted to the Nile Delta flood plain".
- The 4th rock unit is the undistinguishable Quaternary, where the thickness is +2Om and facies are mainly wadi deposits, alluvial fan deposits, desert detritus and desert crust.

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استخدام تقنية الرصد الكهربائي الرأسي لاستكشاف المياه الجوفية

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تم استخدام تفسير ثلاثة وأربعين محطة جيوكهربية تم إضافتها بيانات عشرين بئر تم حفرهم, لتحديد بعض الخصائص الهيدروليكية الهامة للطبقات المياه الجوفية, مثل المقاومة, والخصائص الصخرية, والقوام الذي اعتمد علي كميات الرمال والطين, ومحتوي الرطوبة, والوصلية الهيدروليكية لتوضيح المناطق التي لديها خريطة في منطقة وادي النطرون. لان تطبيق تقنية القياس الجيولوجية مهم جداً في تقييم تباين خصائص طبقات المياه في المنطقة الواسعة وفي وقت قصير, ويمكن لهذه الطريقة توقع أعماق المزيد من المياه سواء بشكل أفقي أو رأسي.من نتائج قياس المقاومة الكهربائية لهذه التربة تم التوصل الي العلاقة بين المقاومة الكهربية (الموصلية الكهربية) والموصلية الهيدروليكية وذلك لتسجيل قوام التربة,واظهرت النتائج ارتباط قوياً بينهما, وبتطبيق العلاقات التجريبية الناتجة التجارب الحقلية تصنيف المنطقة إلي خمسة أجزاء محلية, وفقاً لخصائصهم الفيزيائية ودرجات توزيعهم. فقد اتسم الجزء الأول بقيم للمقاومة تراوحت بين ٢٥ و١٠٠ أوم, واتسم الجزء الثاني بقيم للمقاومة تراوحت بين ١٠٠ و٢٠٠ أوم, كما اتسم الجزء الثالث بقيم مقاوميه تزيد عن ٢٠٠ أوم,. كما اتسم الجزء الرابع بقيم للمقاومة تراوحت بين ١٠-٢٥ أوم. كما اتسم الجزء الخامس بقيم للمقاومة أقل من ١٠ أوم.وفقاً لهذه التقنية في هذه الدراسة والنتائج, يوصي البحث استخدام مصفوفة شلمبرجر مع الأخذ في الحسبان المسافة بين الأقطاب الكهربية المحتملة التي ينبغي أن تكون ثابتة عند وجوب تحرك الأقطاب الكهربية الحالية لكن يفترض أن تكون مسافة متناهية الصغر. كما ينبغي تطبيق هذه الفرضية في قياس مثل هذه الدراسات للحصول علي دقة مرتفعة في تسجيل وتحديد الخصائص الفيزيائية الأفقية والرأسية للتربة محل الدراسة.أيضاً, ينبغي الأخذ في الحسبان القيام بمثل هذه الدراسات, تناول المقاومية الواضحة التي تم قياسها في تقدير الخصائص الفيزيائية للتربة بشكل مباشر. كما يمكن استخدام العلاقات التجريبية الناتجة في حساب النفاذية والانتقالية, إذا تم التحقق من دقة القياس والتفسير. بشكل عام, يمكن استخدام هذه الدراسة بشكل كبير في اكتشاف الخصائص الفيزيائية للتربة في القطاع الضحل ودراسة الحالات المختلفة لمشاكل تشبع التربة بالمياه وتحديد أسباب وطرق الحل وكذلك التنبؤ بمثل هذه المشاكل.