

How Efficient is an Integrative Approach of GIS and Resistivity Data in Groundwater Exploration? A Case Study of Esna, Luxor, Egypt

M. Attwa^{1*}, M. El-Bastawesy², A.M. Abd El-fattah³

¹ Environmental Geophysics Lab. (ZEGL), Geology Department, Faculty of Science, Zagazig University, Egypt

²Geology department, The National Authority for Remote Sensing and Space Sciences (NARSS)

³Geology Department, Faculty of Science, Aswan University, Egypt

*Corresponding author

Email: attwa_m2@yahoo.com

Keywords: GIS, DC Resistivity Sounding, Groundwater Exploration, Esna,

Presently, Geographical Information System (GIS) technique and direct current (DC) resistivity soundings are widely used for characterizing the groundwater aquifers. In this study, an integrated suite of quantitative morphometric analysis and DC resistivity data is used to evaluate the hydrogeological conditions at western part of Esna area, Luxor, Egypt. The geo-hydrological characteristics are assessed and an attempt is made to identify the groundwater potential zones through geo-morphometric specs. Geomorphological analysis of the drainage network of the area points out to the existence of five hydrographic basins. According to the morphometric analysis of drainage basins results, DC resistivity measurements in the form of 1D survey are carried out to demonstrate the subsurface layer distributions and delineate the groundwater aquifers in the main basin of the area. The DC inversion results indicate that the main Pleistocene aquifer overlies the saline Pliocene-Pleistocene aquifer. Further, an integrated relationship between salinity and electrical resistivity is established. The obtained results can serve as a basis for monitoring, planning and management of water resources in this area, and as a whole, they constitute an encouraging example using an integrated approach of morphometric and resistivity data in groundwater exploration.

How efficient is an integrative approach of GIS and resistivity data in groundwater exploration? A case study of Esna, Luxor, Egypt

M. Attwa¹, M. El-Bastawesy² and A.M. Abd El-Fattah³

¹Geology Department, Faculty of Science, Zagazig University, Egypt

²Geology department, The National Authority for Remote Sensing and Space Sciences (NARSS)

³Geology Department, Faculty of Science, Aswan University, Egypt

Email: attwa_m2@yahoo.com

<https://zagazig.academia.edu/MohamedAttwa>

Mohamed Attwa

Outline

- Aims
- Location /Local geology
- Geographic Information System (GIS) /Morphometric analysis
- DC Resistivity measurements/Inversion
- Geoelectrical Results and discussion
- Conclusions and outlook

OUTLINE

Aim

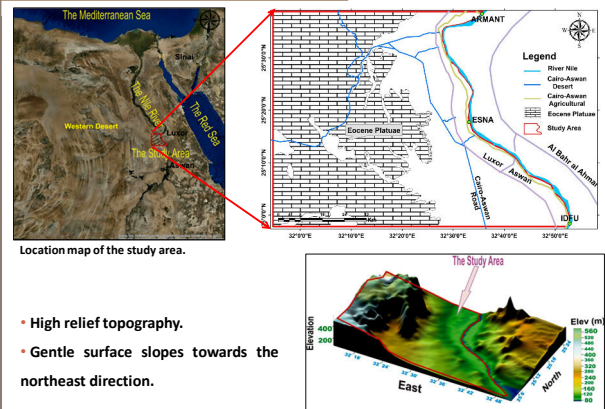
Investigating to what degree an integration of morphometric analysis and DC resistivity data are successful in groundwater exploration/assessment.

Methodology and workflow

- Establishing the high priority area (west Esna) for water flooding potentiality using morphometric analysis. Consequently high chance for runoff water harvesting and increasing groundwater recharge possibilities.
- Delineating the groundwater aquifer/geometry using DC resistivity sounding.
- Establishing a relationship between water salinity and aquifer resistivity to predicate the salinity variations at different depths.
- Establishing 3D visualization model and schematic block diagram of the groundwater conditions of the study area.

AIMS AND WORKFLOW

Location and local geology



LOCATION/TOPOGRAPHY

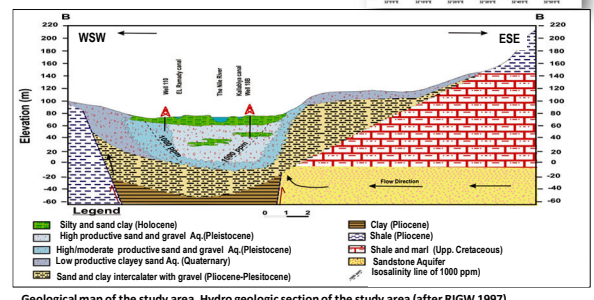
Location and local geology



LOCATION/TOPOGRAPHY

Location and local geology

- The Quaternary aquifer was deposited by the River Nile in a structural low formed during Miocene rifting related to the opening of the Red Sea.



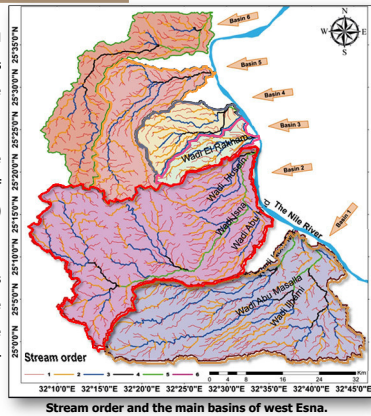
GEOLOGY/HYDROGEOLOGY

GIS /Morphometric analysis

• The advent of geographical information system (GIS) tools opened new path in water resource interpretation.

• Morphometric analysis can be achieved through measurement of linear, aerial and relief aspects (DEM) of basins using ArcGIS.

• The drainage basin analysis is important in understanding the geo-hydrological behavior of drainage basin (D-8 algorithm and Strahler techniques).



MORPHOMETRIC ANALYSIS

GIS /Morphometric analysis

Morphometric Parameter	Formula	Basin 1	Basin 2	Basin 3	Basin 4	Basin 5	Basin 6
Basin Area (A) Km ²		878.59	1024.43	109.47	163.1	353.1	389.54
Basin Perimeter (P) Km		182.11	201.87	62.35	67.72	121.17	154.5
Basin Length (L _b) Km		50.7	53.99	22.56	22.92	35.69	47.1
Stream Length (L _s) Km (All order)		895.35	976.17	124.71	182.72	357.27	360.14
No. of streams (N _s) (All order)		369	423	54	70	161	187
Length of Overland Flow (LoF) Km	$LoF = 1/2D$ $D = L_b/A$	0.51	0.48	0.57	0.56	0.51	0.46

Length of Overland Flow value indicated good surface runoff of the study area

Linear Parameters (one Dimensional)

Drainage Frequency (F _d) / Km ²	N_s/A	0.42	0.413	0.493	0.429	0.456	0.48
Drainage Density (D _d)	L_s/A	1.019	0.953	1.139	1.121	1.012	0.925
Moderate Drainage Density indicates the basins is moderate permeable sub-soil							
Texture ratio (R _t)	N_s/P	1.554	1.650	0.593	0.753	1.048	0.926
Drainage Texture (D _t)	N_s/P	2.026	2.095	0.866	1.034	1.329	1.21
Drainage Intensity (D _i)	F_d/D_d	0.412	0.433	0.433	0.383	0.451	0.519
Infiltration Number (I _n)	$F_d * D_d$	0.428	0.393	0.562	0.481	0.461	0.444

Low value of D_d, F_d, and D_i indicates surface runoff quickly removed from the basins

MORPHOMETRIC ANALYSIS

GIS /Morphometric analysis

Shape Parameter (two Dimensional)

Morphometric Parameter	Formula	Basin 1	Basin 2	Basin 3	Basin 4	Basin 5	Basin 6
Form Factor (R _f)	A/L_b^2	0.342	0.351	0.215	0.311	0.277	0.176
Elongation Ratio (R _e)	$R_e = 2(A/L_b)/A_b$	0.66	0.67	0.523	0.629	0.594	0.473
Compactness Coefficient (C _c)	$C_c = P/2\sqrt{\pi A}$	1.734	1.78	1.681	1.496	1.819	2.209
Runoff Volume	Rational equation *	26165.76	30549.43	6571.49	8916.13	13162.03	11418.5

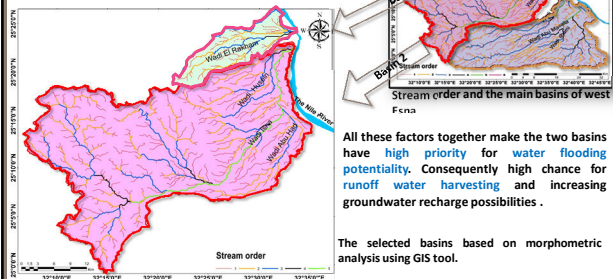
• Rational equation: $V = R * C * A * P$ (1) $R = 1.05 - 0.0053 VA$ (2)

where V is the surface runoff volume, P is the total rainfall depth, C is runoff coefficient, A is the basin area upstream the point of interest, and R is the reduction factor that depends on basin area (HELWA, M., 1993).

MORPHOMETRIC ANALYSIS

GIS/Morphometric analysis

- 1- higher volume of annual flood,
- 2- larger basin area,
- 3- larger basin length,
- 4- lower compactness coefficient,
- 5- lower basin infiltration number,
- 6- Very coarse drainage density,
- 7- coarse drainage texture
- 8- elongated basin shape,
- 9- Higher length of Overland Flow



All these factors together make the two basins have high priority for water flooding potentiality. Consequently high chance for runoff water harvesting and increasing groundwater recharge possibilities.

The selected basins based on morphometric analysis using GIS tool.

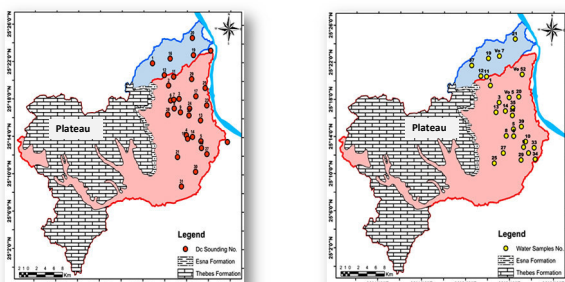
MORPHOMETRIC ANALYSIS

Field data acquisition

Field data:

27 water samples.

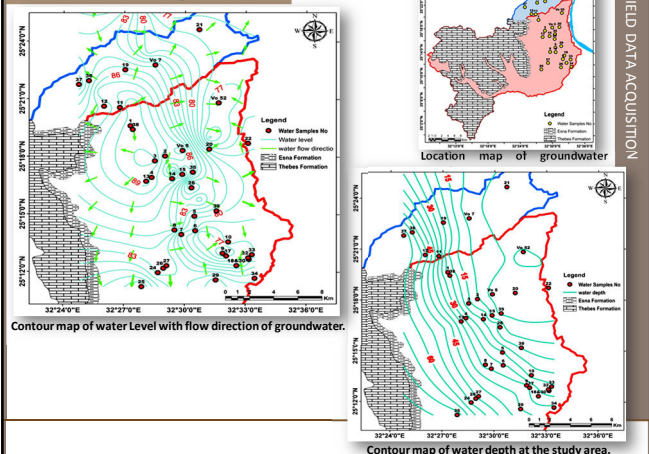
31 Soundings; Schlumberger array; AB/2: 700 m.



Location map of Dc soundings (left) and groundwater samples (right) of the study area.

FIELD DATA ACQUISITION

Field data acquisition



Contour map of water level with flow direction of groundwater.

Contour map of water depth at the study area.

FIELD DATA ACQUISITION

DC Data Acquisition



Syscal R2 instrument.

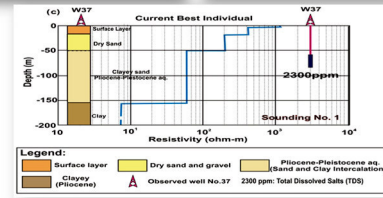
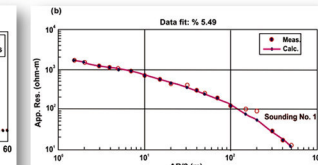
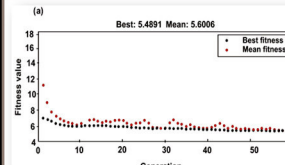


The conditions were extremely difficult due to the resistance contact and inhomogeneity of the surface cover.

Some precautions were carried out as digging a hole, adding water, adding bentonite...etc.

DC DATA ACQUISITION

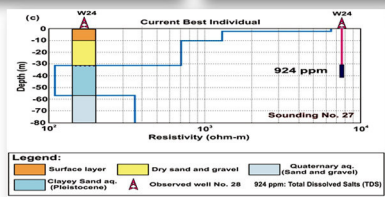
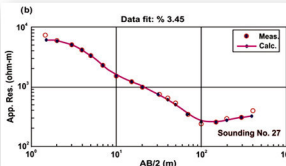
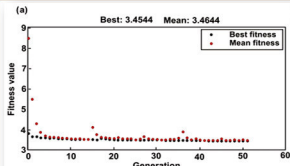
DC Resistivity inversion



Comparison between the interpreted resistivity layers and observed borehole data at sounding no. 1 using GA, the population size and the number of generations were both 50, (Akca and Basokur, 2010).

DC RESISTIVITY INVERSION

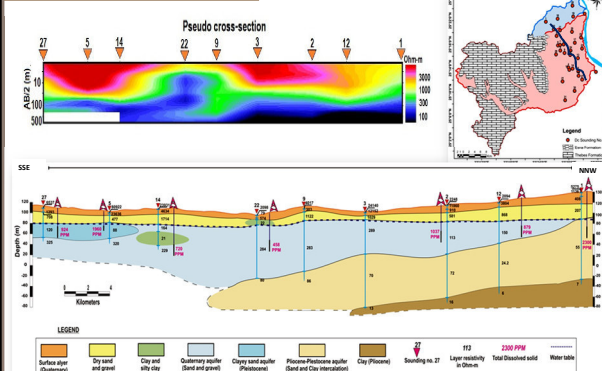
DC Resistivity inversion



Comparison between the interpreted resistivity layers and observed borehole data at sounding no. 27 using GA, the population size and the number of generations were both 50, (Akca and Basokur, 2010).

DC RESISTIVITY INVERSION

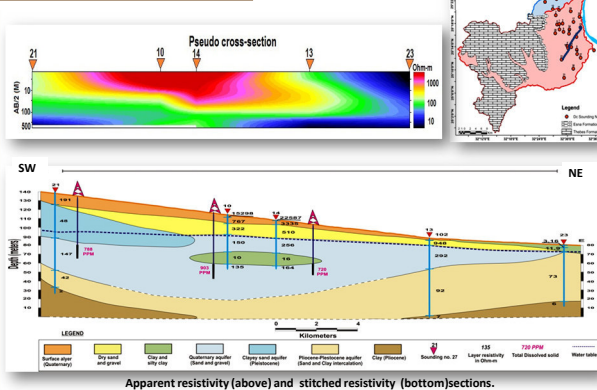
Results / Discussion



Apparent resistivity (above) and stitched resistivity (bottom) sections.

RESULTS / DISCUSSION

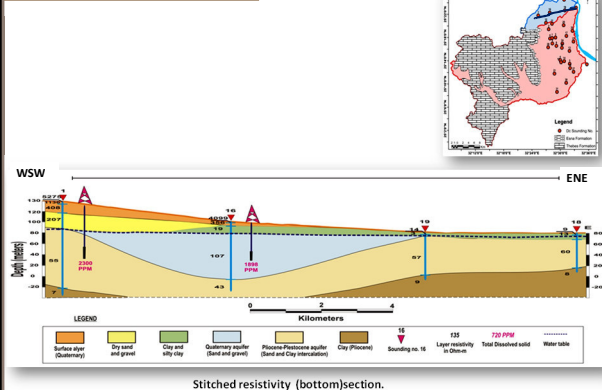
Results / Discussion



Apparent resistivity (above) and stitched resistivity (bottom) sections.

RESULTS / DISCUSSION

Results / Discussion



Stitched resistivity (bottom) section.

RESULTS / DISCUSSION

