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Hydrogeophysical investigation of aquifer potentiality to sustain brackish water supplies for greenhouses in coastal aquifers

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Introduction

The Nile Delta Aquifer (NDA) which is semi-confined due to upper clay layer presence is important source of water supply of the area where population growth is rapid [1,2]. The Quaternary deposits constitute the main aquifer at the ND. Moreover, the shallow NDA is recharged mainly by infiltration of excess irrigation water, which provides about 85% of total groundwater abstractions in Egypt. The shallow NDA is composed of thick clayey sand to sandy layer, about 50 m in average thickness, covered by a clay cap. About 6.1 Billion Cubic Meter per year (BCMYear^{-1}) is annually extracted from the aquifer and reached to 7BCM in 2016 **[3, 4]**. The NDA thickness increases in a northward direction (900 m average thickness). On the other hand, the saturated thickness of this aquifer ranges between 100 and 200 m at the southern part of the eastern part of the ND. . The Holocene deposits include the Nile clay, silt and sandy clay. The thickness of this unit ranges from 5 m to 30 m. **[5, 6]**. This research work in intended to explore the potentiality of groundwater existence in Zagazig City where the greenhouse project will be implemented to act as a supply for a greenhouse project.

Methods and Materials

Nile delta aquifer

The NDA considers one of the largest groundwater reservoirs in the world [1, 2]. The study area is located between Latitudes 30˚ 34`54.20`` and 30˚ 35`01.72``N, and longitudes 31˚30`59.40`` and 31˚31`07.92``E where the greenhouse will be implemented. It has an area of 19,000 m^2. The stratigraphy of the study area is divided to Pliocene sediments, an upper fluviatile sequence (late Pliocene), and Quaternary (Pleistocene and Holocene) sediments lying over the Pliocene sediments. The sediments constitute variable proportions of sand, clay and gravel with lateral variation and variable thicknesses [7]. The thickness of the Quaternary aquifer varies from 200m in the South to 1000m in the North **[8]**. The main aquifer in the study area is the Quaternary aquifer. The aquifer is composed of loose sand with gravel related to the old litho-facies [7].

Geophysical data acquisition and interpretation

Direct current resistivity (DCR) surveys are involving direct current injection by electrodes at the ground surface. In general, two pairs of electrodes are required: current (A and B) and potential (M and N) electrodes. Here, stainless steel electrodes were used for data acquisition at the study site (**Fig. 1a**) using Geomative GD-20 system (Geomative CO., LTD.), which is a multichannel multi-electrode resistivity system (**Fig. 1b**).

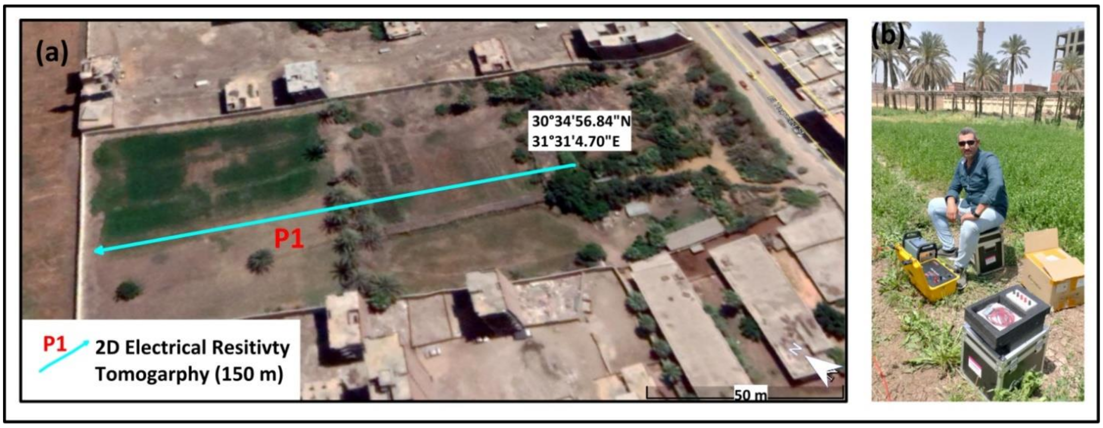

Fig. 1: (a) Location map of the study site showing the 2D-ERT profile (P1)and (b) Field photos showing the field data acquisition using Geomative GD-20 resistivity meter at the study site.

The measurements location was marked using GPS positioning. The 2D-ERT was carried out using Wenner electrode configuration, which is widely used for hydrogeological investigations [9]. The 2D-ERT profile length was 150 m long. The minimum electrode spacing was 5 m using 30 electrodes. The maximum electrode spacing, a, was 45 m i.e., the maximum data level (n) was 9.

Results and Discussion

The 2D-DC data were processed and inverted using the 2Dinversion algorithm DC2DInvRes [**10**] which is based on numerical modeling techniques using finite-difference method applying smoothness constraints Gauss-Newton inversion scheme [**11**]. **Fig.2** shows the inversion results of 2D-ERT P1. The 2D-ERT P1 shows three main geoelectrical layers. Considering the available borehole information, the upper relative low resistivity layer (< 7 ohm-m) can be attributed to clay layer with 6 m average thickness. This layer is followed by a medium resistivity layer (10-20 ohm-m) with 15 m average thickness corresponding to saturated clayey sand (i.e., low permeability). At about 20 m average depth, a high resistivity layer (> 25 ohm-m) can be observed, which is attributed to saturated sand (i.e. major aquifer).

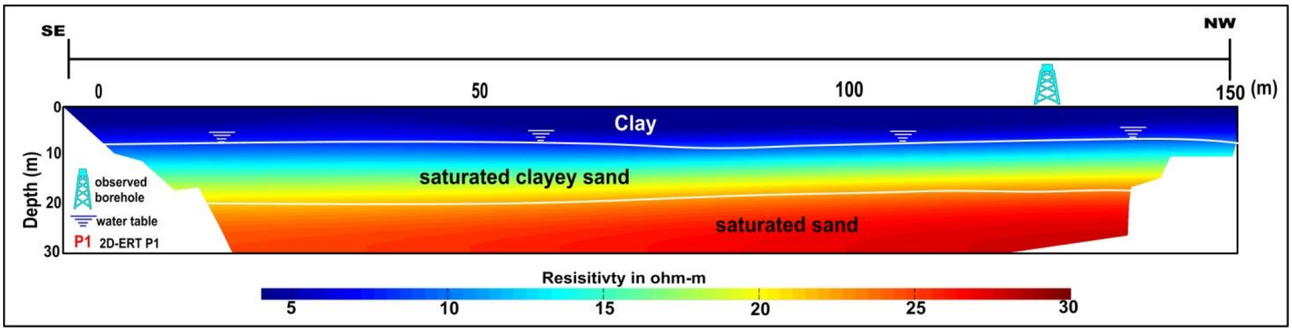

Fig. 2: 2D interpretation of the 2D-ERT P1 (for location, c.f. Fig. 1a), obtained from inversion of Wenner data set.

Conclusions

Greenhouse technology is developed to support the agriculture sector and overcomes the water shortage in arid and semi-arid regions where the water supplied for this system is brackish water. This study was applied in NDA, Egypt using hydrogeophysical investigations using DCR technique to identify the shallow NDA potentiality. The geophysical data acquisition was achieved using Geomative GD-20 system and interpreted using a conventional inversion. The results of 2D-ERT indicated that the upper low resistivity layer can be attributed to clay deposits. This layer is followed by medium resistivity layer (10-20 ohm-m) corresponding to saturated clayey sand (low permeability) The third geoelectrical layer represents high resistivity values (more than 25 ohm-m) corresponding to saturated sand (major aquifer). Accordingly, hydrogeophysical invewstihation is essential to assess the aquifer potentiality and sustain the brackish water supplies for greenhouses in coastal aquifers.

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