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Management of water resources to control groundwater levels in the southern area of the western Nile delta, Egypt

Mohamed M. Sobeih [a], Nahed E. El-Arabi [b], Esam El Deen Y. Helal [a], Basma S. Awad [c,*]

[a] *Civil Engineering Department, Faculty of Engineering, Minufiya University, Egypt*
[b] *National Water Research Center (NWRC), Egypt*
[c] *Channel Maintenance Research Institute, National Water Research Center (NWRC), El-Kanater El-Khairia, Egypt*

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Abstract

The present study was initiated with the objective of simulating and predicting the effect of future development on the groundwater flow and levels. This supports applications for future planning and wise management of water resources. The study area extends south of El Nubariya canal including Sadat City area and its vicinities in the western Nile delta region. A numerical groundwater flow model (MODFLOW) has been employed to simulate flow and get the budget of groundwater in the study area. The model showed that about 28,101,041 m^3/day of surface water is infiltrated to groundwater dominantly from canals and excess irrigation water. About the same quantity (28,101,052 m^3/day), is discharged from groundwater through production wells, open drains and through some reaches of canals. Three development scenarios were simulated to give predictions of the impact of future increasing recharge, construction of new canal and new open drains, and also increased pumping on the groundwater levels in the study area.
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Keywords: Groundwater; Aquifer; Logging; Drought; MODFLOW; Management

1. Introduction and objectives

In the southern area of the western Nile delta region, groundwater is the main source of water supply for domestic, industrial and agriculture use. Increased groundwater abstraction causes local troughs due to drawdown and dryness of the groundwater (Soliman et al., 2014). Intensive expansion in land reclamation, increased population and construction of new industrial projects cause changes in water demand and in the groundwater regime. Ministry of Water Resources and Irrigation (MWRI, 2007) introduced the west delta water conservation and irrigation rehabilitation project aiming to implementation of a pipe network to transfer surface water to irrigate about 107,000 hectares (264,403 feddans) located in the South of the West Delta. This will be reflected on rising of groundwater levels accompanied by formation of local groundwater mounds and logging problems and reversal of the groundwater flow directions. Efficient management of the water resources is required to deal with these problems. Dawoud et al. (2005) studied GIS-based groundwater

* Corresponding author.
E-mail addresses: sobeih@yahoo.com (M.M. Sobeih), elarabinahed@gmail.com (N.E. El-Arabi), esameman@yahoo.com (E.E.D.Y. Helal), basma_samir2011@yahoo.com (B.S. Awad).

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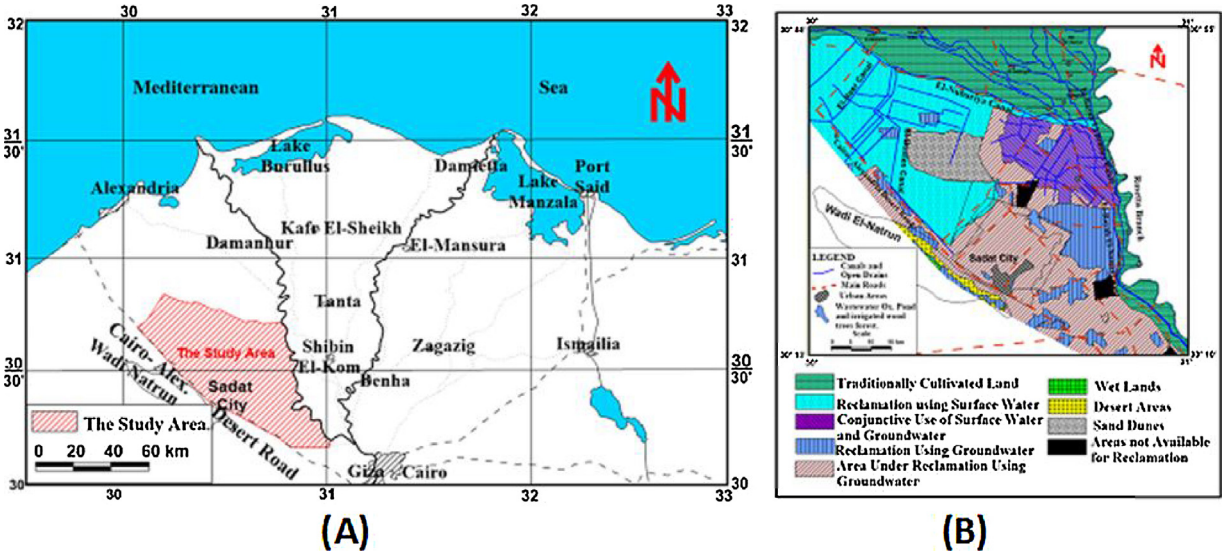

Fig. 1. (A) Location and (B) landuse maps of the study area.

management model for western Nile delta and test two alternative management scenarios for conserving the aquifer system. El Azizy et al. (2009) studied water resources management using remote sensing, case study: El Nubariya project. Gad (2012) studied assessment of the environmental impacts on the groundwater resources in west of the Nile Delta, Egypt. El Arabi and Morsy (2013) evaluated the current water potential and predicted the future groundwater potential till 2020 to solve the shortage of water problems, especially in the ends of El Nubariya canal.

In the present study, it is crucial to study the hydrogeological regime and assess the environmental impacts of development activities. This aims to promote recycling, minimize pollution, and increase groundwater quantity and quality alongside maintaining a sustainable economic development. Groundwater modeling is the best tool to predict the response of the groundwater aquifer system under the proposed future management scenarios and helps in formulating the management strategy. MODFLOW model has been employed through Aquaveo GMS-based model to simulate hydrogeological conditions. Different mitigation measures have been used to give practical methods for adjusting and control the groundwater levels and treat the problems of water logging and inundation. Khadri and Pande (2016) used MODFLOW software to study groundwater flow modeling for calibrating steady state in a case study of Mahesh River basin, India.

2. Study area description

The study area is bordered by Rosetta Branch to the east, the Cairo–Alex desert road to the west, El Nubariya and El Nasr canals to the north and extends southward in the western Nile delta region as shown in Fig. 1A. The study area is characterized by a low relief and slope from southwest to northeast and from west to east. The ground elevation varies from less than sea level west of Sadat City to more than 50 m above mean sea level at the southwestern periphery nearby Cairo–Alex desert road. Topographic features cause variations in depth to groundwater and presence of water logged areas and environmental problems. The traditionally cultivated lands exist in the northeastern part of the study area. Newly reclaimed lands dominate the area using surface water, groundwater, or conjunctive use of surface water with groundwater as shown in Fig. 1B. Drainage water from open drains is partly reused for irrigation to cover the shortages of the irrigation water. An industrial area was constructed in Sadat City including many industrial activities.

3. Physical and geological conditions

Meteorological data of the western Nile delta region indicate that temperature ranges between 28.26 °C in May and 13.82 °C in January, rainfall records 100–200 mm/day take place intermittently at intervals hardly exceeding a couple of hours. The average relative humidity ranges between 45% in May and 68% in November. The average evaporation

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