3D Paleohydrogeological modelling of the Nile Delta

Joeri van Engelen[1,2], M.F.P. Bierkens[1,2], G.H.P. Oude Essink[1,2]
[1]Department of Physical Geography, Utrecht University, Utrecht, The Netherlands
[2]Department of Groundwater Management, Deltares, Utrecht, The Netherlands

ABSTRACT

The Nile Delta in Egypt is a heavily populated area with high agro- and socio-economic importance for Egypt. Though its lands are traditionally irrigated with surface water from the Nile, the discharge of this river is reduced due to the building of large upstream dams, such as the Aswan dam in Egypt (1970), the Merowe dam in Sudan (2011), and possibly in the future the Grand Ethiopian Renaissance Dam in Ethiopia (under construction, estimated to finalized end of 2018). This reduced surface water availability will probably lead to an increased use of groundwater for irrigation. Adding to this stress on the groundwater system, there is a strongly growing population which further amplifies extraction rates. Furthermore, there is the estimated sea level rise. These stresses will cause the country to increasingly rely on groundwater in the near-future. Therefore, an assessment of the current and future status of the groundwater resources is critical to safeguard these precious resources for the coming generations.

Several studies found that the area is vulnerable to salt water intrusion (e.g. Kashef, 1983; Sefelnasr and Sherif, 2014) due to the shallow topography of the area and the high transmissivity of the aquifer. Furthermore, hydrogeochemical measurement campaigns have shown the strong influence of paleohydrogeologic processes on the current groundwater salinity distribution (Geirnaert and Laeven, 1992; Barrocu and Dahab, 2010; Geriesh et al., 2015). However, the previous hydrogeological models created for this area ignored the influence of the paleohydrogeology, likely due to computational limitations, even though some studies show a paleo reconstruction increases our understanding of the groundwater system considerably (Tran et al., 2012; Delsman et al., 2013; Larsen et al., 2017; Vallejos et al., 2017). In this study, we model the complete Nile Delta Aquifer in 3D over several thousands of years. To tackle the computational burden this model created, we use the new iMOD-SEAWAT code (Verkaik et al., 2017), that allows parallel computation on a super computer. Calculations were conducted on the Dutch National Supercomputer “Cartesius”. In this presentation, we show the results of our efforts and compare these to a database, compiled of data from the published articles. The influence of paleohydrogeological circumstances and the (uncertain) lithology is shown.

REFERENCES

Barrocu, G., Dahab, K., 2010. Changing climate and saltwater intrusion in the Nile Delta , Egypt, in: Makato, T., Holman, I. (Eds.), Groundwater Response to a Changing Climate. Taylor & Francis, pp. 11–25.

Delsman, J.R., Hu-A-Ng, K.R.M., Vos, P.C., De Louw, P.G.B., Oude Essink, G.H.P., Stuyfzand, P.J., Bierkens, M.F.P., 2013. Paleo-modeling of coastal saltwater intrusion during the Holocene: An application to the Netherlands. Hydrol. Earth Syst. Sci. 18, 3891–3905. doi:10.5194/hess-18-3891-2014

Geirnaert, W., Laeven, M.P., 1992. Composition and history of ground water in the western Nile Delta. J. Hydrol. 138, 169–189. doi:10.1016/0022-1694(92)90163-P

Geriesh, M.H., Balke, K.-D., El-Rayes, A.E., Mansour, B.M., 2015. Implications of climate change on the groundwater flow regime and geochemistry of the Nile Delta, Egypt. J. Coast. Conserv. 19, 589–608. doi:10.1007/s11852-015-0409-5

Kashef, A.-A.I., 1983. Salt-Water Intrusion in the Nile Delta. Groundwater 21, 160–167. doi:10.1111/j.1745-6584.1983.tb00713.x

Larsen, F., Tran, L.V., Van Hoang, H., Tran, L.T., Christiansen, A.V., Pham, N.Q., 2017. Groundwater salinity influenced by Holocene seawater trapped in incised valleys in the Red River delta plain. Nat. Geosci. 10. doi:10.1038/ngeo2938

Sefelnasr, A., Sherif, M., 2014. Impacts of Seawater Rise on Seawater Intrusion in the Nile Delta Aquifer, Egypt. Groundwater 52, 264–276. doi:10.1111/gwat.12058

Tran, L.T., Larsen, F., Pham, N.Q., Christiansen, A. V., Tran, N., Vu, H. V., Tran, L. V., Hoang, H. V., Hinsby, K., 2012. Origin and extent of fresh groundwater, salty paleowaters and recent saltwater intrusions in Red River flood plain aquifers, Vietnam. Hydrogeol. J. 20, 1295–1313. doi:10.1007/s10040-012-0874-y

Vallejos, A., Sola, F., Yechieli, Y., 2017. Influence of the paleogeographic evolution on the groundwater salinity in a coastal aquifer. cabo de gata aquifer, se spain. J. Hydrol. doi:10.1016/j.jhydrol.2017.12.027

Verkaik, J., Van Engelen, J., Huizer, S., Oude Essink, G.H.P., 2017. The New Parallel Krylov Solver for SEAWAT, in: AGU Fall Meeting 2017.

Contact Information: Joeri van Engelen. Utrecht University, Department of Physical Geography, Heidelberglaan 2, Utrecht, 3584 CS Utrecht, Phone: +31 30 2532749, Email: joeri.vanengelen@deltares.nl