



Groundwater contaminant transport in the Nile Delta aquifer|

Samar Mohamed Gomaa¹, Taher Mohamed Hassan¹, Essam Yousri Helal²

¹Research Institute for Groundwater, National Water Research Center, Cairo, Egypt. ²Civil Engineering Department, Faculty of Engineering, Menoufia University, Egypt.

المخلص العربي :

لاقت مؤخرا مصادر المياه الجوفية اهتماما واسعا في مصر، حيث أصبح لها الأولوية لتكون مركز الاهتمام. تعتبر مشكلة انتقال الملوثات في الخزانات الجوفية إحدى المشكلات الهامة التي لها تأثيرا مباشرا على نوعية المياه الجوفية. كما أن التزايد في التعداد السكاني الذي تتعرض له مصر في السنوات الأخيرة أصبح بشكل لا يصدق وسبب في تضخم المشكلة وخاصة في منطقة دلتا النيل. ناقشت العديد من الأبحاث العلمية هذه المشكلة من وجهات نظر مختلفة في السنوات الأخيرة حيث استخدموا العديد من النماذج الرقمية لتمثيل الخزانات الجوفية التي تتعرض لمثل هذا النوع الخطير من الملوثات ، وتختلف أنواع الملوثات طبقا للمنطقة التي يتواجد بها الخزان الجوفي وكذلك العوامل البيئية المحيطة به. مثل بعض الباحثين هذه المشكلة بواسطة النماذج الرقمية في التطبيقات على نظم الخزانات الجوفية ذات النطاق الواسع ، واستخدم آخرون النماذج الفيزيائية للجوانب النظرية و فحص حساسية المعاملات التي تؤثر على عملية انتقال الملوث. هذا المقال يعرض بعض الأبحاث التي تناقش مشكلة انتقال الملوث وكيفية تمثيلها وإدارتها للتحكم فيها والتخفيف من أثارها، كما يعرض العديد من الأنواع المختلفة لمشكلة انتقال الملوث.

Abstract :

Lately, there is an interest in groundwater resources in Egypt. It has an advanced priority to be focused on. One of the most important issues that have a direct impact on groundwater quality is contaminant transport. The incredible population increase that Egypt is exposed to in the recent years has magnified the problem especially in the Nile Delta region. Many recent researches discussed the problem from various different perspectives. They conducted lots of models to simulate the groundwater aquifers exposed to such dangerous contamination. The types of contaminant differ according to the location of the groundwater aquifer and the environmental effects surround it. Some researches simulated the problem using numerical models for applications and huge aquifer system domains; others used the physical models for theoretical issues and to check the sensitivity of the parameters that affect the

contaminant transport mechanism. This article presents some of the researches disused the contaminant transport problem and how they simulated and managed it to control or mitigate its impacts. Moreover, it shows many different types of contaminant transport problems.

Keywords: Contaminant transport; Groundwater; Physical modeling; Nile Delta aquifer; Numerical modeling.

Introduction

Water represents the only key for human life on the earth. Humans and all the creatures can't live without its existence. The freshwater percentage on the planet is only about 3% of the earth's water. The majority of the freshwater on the planet that can be used for drinking and agricultural works depends on surface water such as rivers, canals. The groundwater comes in the second –class of the important water resource. Groundwater is essential in the regions that suffer the shortage in the water existence. The arid and semi-arid areas seek to suffice all their water demand depending on such resources (Abdel-Shafy and Kamel, 2016). Nile Delta aquifer is considered the main aquifer system that the delta of Egypt can exploit. The aquifer is exposed to many dangerous contamination resources including Stalinization and solute transport problems. This may cause significant changes in the groundwater quality and the surface water as well. The aquifer supplied about 6.1 BCM as total annual groundwater extraction (Negm et al., 2019). Nile Delta has a heavy agricultural works because of the high population density so that the water quality in decreasing with the existence of may pollution resources. Industrial activities, agriculture and domestic polluted effluents have the biggest share in the water contamination of the Nile Delta aquifer (Tourism, 2013). Moreover, the Nile Delta aquifer has a connection with the Mediterranean Sea in the north of Egypt; there is another danger where the salt water exists and the intrusion of salt water is probable especially with the continuous abstraction (Abdel-Shafy and Kamel, 2016; Mohamed El-Kiki, 2018).

Contaminant transport case studies

Some recent studies showed that the concentration of the parameters represents the water quality and heavy metals exceed the WHO standards for drinking water. Others

indicated that some regions became no longer fit for the agricultural activities (Negm et al., 2019). Zedan et al., (2013) investigated the groundwater pollution in the central region of the Nile Delta aquifer. The research depended on laboratory and numerical modeling to examine the distribution of the chemical contaminants in the shallow groundwater of the aquifer. The analyzed samples indicated that the contaminant transport is directly affected by the hydraulic properties and gradient of the flow and the most of the contaminant flows towards the northern-west direction of the region. On the other hand, Abo-El-Fadl, (2013) examined the possibility of groundwater contamination in the eastern region of the Nile Delta aquifer near Bahr El-Baker reservoir. 56 groundwater samples were analyzed and the results indicated that the salinity was high in the case study and because its location is very near from a contaminated surface water resource and there was a high possibility for contaminant transport in the region. (Zeidan, 2017) stated that the Nile Delta aquifer suffers the high concentrations of the Nitrate and it reached the critical levels and exceeded the standards for drinking water (0.5 mg/L). The research added that the contaminant flow is towards the northern west direction. The main contamination sources in the region are the sewage treatment plant's water, soil nitrogen and artificial fertilizers. Armanuos et al. (2016) conducted a statistical analysis of the groundwater quality in the western region of the Nile Delta aquifer. The research aimed to illustrate the factors that have direct impact on the groundwater quality in the region. The factor analysis was performed for 19 different parameters to examine the origin of groundwater pollution. The results indicated that the mineralization, mining and the salinity due to seawater intrusion are the first two factors cause the pollution. They are followed by the industrial and agricultural wastes.

Negm et al., (2019); Negm, (2019); Nofal et al., (2015); Sakr et al. (2004) Sefelnasr and Sherif, (2014) and Zedan et al., (2013) mentioned that there is a danger threat the northern region of the Nile Delta Aquifer. The researchers discussed the problem from many different perspectives. Modeling and isotope analysis proved that the groundwater Stalination ability is very high especially with abstracting the groundwater by intensive pumping rates and the problem need to be managed.

Contaminant transport mitigation

Mansour et al., (2018) used two unequal sheet piles and a horizontal floor with no permeability at the surface as a trial to mitigate the contaminant transport and reduce its effect. A numerical model was created for two different cases; a solute transport considering the advection and diffusion and another one for only advection concern. The research used the analytical solution besides the laboratory experiments to verify the results of the numerical solution. The results indicated that the time of contaminant arrival is directly affected by the distance between the first sheet pile and the contaminant sources and the time reduced to the half by using two unequal sheets instead of only single one.

Allam et al., (2019) examined how the inclined barrier walls can retard the contaminant movement through the porous media. The research depended on changing the barrier wall arrangement to examine the impact of using only single inclined one and two successive barriers with different inclination ratio. Moreover, the impact of the distance between the contaminant resource and the barrier wall on the migration time. A numerical model was built for that target. The results indicated that the inclination ratio has a major effect on the migration time.

References

- Abdel-Shafy, H.I., Kamel, A.H., 2016. Groundwater in Egypt Issue: Resources, Location, Amount, Contamination, Protection, Renewal, Future Overview. *Egypt. J. Chem.* 59, 321–362. <https://doi.org/10.21608/ejchem.2016.1085>
- Abo-El-Fadl, M., 2013. Possibilities of Groundwater Pollution in Some Areas , East of Nile Delta , Egypt 1, 1–21.
- Allam, A., Helal, E., Mansour, M., 2019. Retarding contaminant migration through porous media using inclined barrier walls. *J. Hydrol. Hydromechanics* 67, 339–348. <https://doi.org/10.2478/johh-2019-0020>
- Asaad M. Armanuos, Abdelazim Negm, and O.C.S.V., 2016. Groundwater Quality Investigation Using Multivariate Analysis — Case Study: Western Nile Delta Aquifer, Egypt. *Int. J. Environ. Sci. Dev.* 7, 1–9. <https://doi.org/10.7763/ijesd.2016.v7.732>

- Mansour, M.M., Ellayn, A.F., Helal, E., Rashwan, I.M.H., Sobieh, M.F., 2018. Delaying solute transport through the soil using unequal double sheet piles with a surface floor. *Ain Shams Eng. J.* 9, 3399–3409. <https://doi.org/10.1016/j.asej.2018.10.003>
- Mohamed El-Kiki, 2018. Review Article Effect of Sea Water Intrusion on Nile Delta and Possible Suggested Solutions.
- Negm, A., Sakr, S., Abd-Elaty, I., Abd-Elhamid, H., 2019. An Overview of Groundwater Resources in Nile Delta Aquifer, in: *Handbook of Environmental Chemistry*. https://doi.org/10.1007/698_2017_193
- Negm, A.M., 2019. Groundwater in the Nile Delta.
- Nofal, E.R., Amer, M.A., El-Didy, S.M., Fekry, A.M., 2015. Delineation and modeling of seawater intrusion into the Nile Delta Aquifer: A new perspective. *Water Sci.* 29, 156–166. <https://doi.org/10.1016/j.wsj.2015.11.003>
- Sefelnasr, A., Sherif, M., 2014. Impacts of Seawater Rise on Seawater Intrusion in the Nile Delta Aquifer, Egypt. *Groundwater* 52, 264–276. <https://doi.org/10.1111/gwat.12058>
- Tourism, P.-, 2013. CURRENT SITUATION OF WATER POLLUTION AND 37, 95–119.
- Zedan, B.A., Aly, A.I.M., Ibrahim, M.H., Ahmed, M.A., Ghoraba, S.M., 2013. GROUNDWATER QUALITY MANAGEMENT IN MIDDLE NILE DELTA UTILIZING ENVIRONMENTAL ISOTOPES AND SOLUTE TRANSPORT MODELING Summary : State of Art.
- Zeidan, B.A., 2017. Groundwater degradation and remediation in the Nile Delta aquifer. *Handb. Environ. Chem.* 55, 159–232. https://doi.org/10.1007/698_2016_128