Surface Water-Groundwater Interaction Modeling Approach using Coupled Modeling Techniques: Quaternary Aquifer, Minia, Egypt

Ahmed Mohamed[1,*], Ahmed Sefelnasr[2], Esam El-Sayed[1], Esam Ismail[1]

[1]Geology Department, Faculty of Science, Minia University, Egypt
[2]Geology Department, Faculty of Science, Assiut University, Egypt
[*]Corresponding author

Email: ahmed.mohamed@mu.edu.eg

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Arid and semi-arid regions present special challenges for water management. They are areas where water is at its most scarce, and face great pressures to deliver and manage freshwater resources. In these regions, interaction between surface water (SW) and groundwater (GW) plays an important role in the ecohydrological system. Surface water models have been used to assess surface-water resources and to make management decisions. Such assessments and decisions are often made with a simplistic representation of the groundwater hydrology and its interaction with surface and atmospheric hydrology. Similarly, groundwater flow models have been used to assess groundwater resource problems and to manage and develop groundwater supplies. These are several important hydrologic processes in between that play a vital role in the exchange of water between the two, by nature connected systems. These processes are important for assessing the effects of groundwater development on basin-scale water resources. Understanding the complex behavior of the integrated SW-GW system is very important to the regional water resources management and to tackle these new challenges especially in a country with very limited water resources such as Egypt. Consequently, integrated modeling is a highly desired approach. The purpose of this study is to develop a sophisticated SW-GW coupled numerical model to help investigate the impacts of this exchange on the Quaternary aquifer and to study the recharge possibilities of the aquifer as well as its vulnerability to pollution in Minia Governorate, Egypt. To better understand SW and GW interactions in the study area, a coupled model was developed using the Groundwater/Surface-water FLOW model, GSFLOW, by integrating the Precipitation-Runoff Modeling System (PRMS) and the Modular ground-water flow model MODFLOW-2005. PRMS simulates the distribution of water from the top of the plant canopy to the bottom of the soil zone on the basis of hydrologic and climate variables, such as precipitation, air temperature, potential solar radiation, and evapotranspiration. MODFLOW-2005 simulates the distribution of water from the base of the soil zone, through the unsaturated zone, to the saturated zone, and the discharges of water to streams and the land surface. In GSFLOW, separate equations are coupled to simulate horizontal and vertical flow through the soil zone, gravity-driven vertical flow through the unsaturated zone, and three-dimensional groundwater flow through the saturated zone. GSFLOW was designed to simulate the most important processes using a numerically efficient algorithm, thus allowing coupled simultaneous simulation of flow.

The GSFLOW model has been calibrated and tested against the steady state condition. However, it was difficult to obtain a steady state condition for this model. Four scenarios were suggested for the prediction simulations to investigate the impact of the climatic, social, political, and development changes on the water regime within the area.