Groundwater Flow and Management Modeling in a River Island of Orissa

ABSTRACT

The present study focuses on modeling of groundwater flow and management scenarios in the 'Kathajodi-Surua Inter-basin' located in Mahanadi Delta of Orissa, eastern India. The study includes in-depth hydrologic and hydrogeologic investigations, development of a groundwater-flow simulation model, development of artificial neural network (ANN) models for groundwater level forecasting, comparison of these two modeling approaches, and development of a simulation-optimization model for optimal land and water resources utilization in the river basin. In the absence of groundwater level data, weekly groundwater monitoring at 19 sites over the basin for a period of 3 years and 9 months was carried out as part of the study. The hydrogeologoic analysis of the basin indicated the existence of a leaky confined aquifer comprising medium to coarse sand and having a thickness of 20 to 55 m. The analysis of pumping test data indicated aquifer hydraulic conductivity ranging from 11.3 to 96.8 m/day and storage coefficient ranging from 1.43×10^{-4} to 9.9×10^{-4}, suggesting significant aquifer heterogeneity. A majority of study area exhibits stream-aquifer interaction and the groundwater quality is suitable for irrigation.

The calibration and validation of the groundwater-flow model were done satisfactorily using Visual MODFLOW software. The sensitivity analysis of the model revealed that the model is most sensitive to the changes in the river stage and is least sensitive to the changes in the specific storage. The groundwater-flow simulation indicated that if the existing conditions continue, there is no threat to groundwater lowering in the basin in the near future. Further, the Bayesian regularization algorithm was found marginally superior to that of the Levenberg-Marquardt and gradient descent with momentum and adaptive learning rate backpropagation (GDX) algorithms for predicting weekly groundwater levels by ANN technique. Although the groundwater prediction by ANN technique was reasonably good for higher lead times (up to 4-week), the accuracy of prediction decreases with an increase in the lead time. A comparison of the numerical model results with those of the ANN models indicated that the ANN models predicted groundwater levels with a greater accuracy than the numerical model for shorter time horizons. The results of simulation-optimization modeling revealed that if the suggested optimal cropping patterns are adopted in the study area, the net annual irrigation water requirements will be reduced by 28, 35 and 40%, and net annual income will be increased by 28, 23 and 17% during wet, normal and dry scenarios, respectively.

Keywords: *Hydrogeologic analysis, stream-aquifer interaction, groundwater-flow modeling, artificial neural network, training algorithms, simulation-optimization modeling, Visual MODFLOW*