Groundwater Flow Modeling Using COMSOL Multiphysics and GMS Software: A Comparison

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Abstract

Introduction:

Groundwater is one of the components of hydrological cycle, which once believed to be the purest water source on earth, has been now contaminated by natural and human activities in most parts of the world. The heterogeneous and anisotropic nature of the of aquifer systems makes it complex to understand the problem. In order to understand the groundwater flow and transport processes of any regional aquifer system under various imposed conditions COMSOL Multiphysics software provides various modules to solve the problem. The Kosi alluvial river basin in Bihar state was considered as a study area (Figure 1). The aquifer parameters like hydraulic conductivity values were given to the model using field data. Finally, the head contours were obtained from the discretized model after solving the governing PDE using MODFLOW and COMSOL Multiphysics. The present study also focuses on the aquifer systems having fractures as one of the complexities has been tried to understand using COMSOL.

Use of COMSOL Multiphysics:

The governing PDE for transient three dimensional groundwater flow in heterogeneous and anisotropic porous medium with source/sink term using the principle of mass conservation and Darcy's law,

The above equation can be implemented using COMSOL Multiphysics using Darcy's law of physics from porous media and subsurface flow from fluid flow module or coefficient form PDE interfaces of mathematics module.

$\partial/\partial t\, (\rho \varepsilon_P) + \nabla \cdot (\rho U) = Q_m$

$U = -k/\mu\, \nabla P$

The same equation in case of fracture flow model will be as given below using COMSOL,

$\nabla_T \cdot (d_f\, \rho U) = d_f\, Q_m$

$U = -k_f/\mu\, \nabla_T P$

Results:

The main results of the present study include steady and transient state groundwater flow modelling of the above study area discretised into 1 km by 1 km in plan with single layer of 100 m aquifer thickness. The groundwater hydraulic head contours were obtained for all the grids using GMS grid approach [1] (Figure 2). An effort has been made to setup the above same model using COMSOL Multiphysics where the GIS futures like Point, line and polygon can be converted into CAD and it will be imported into COMSOL software for further simulation purpose to solve the problem. One of the key comparative results of GMS and COMSOL shown at the conferencing point of two rivers with/without pimping station (Figure 3). Finally a hypothetical flow model having multiple fractures through fractured porous media interacting with/without pumping station developed using COMSOL (Figure 4).

Conclusion:

Thus the Ground water flow modeling of Kosi alluvial fan in Bihar region of India has been studied successfully using MODFLOW 3D GRID approach (GMS) and COMSOL Multiphysics software with available depth to water table data and the aquifer parameters. COMSOL also has other modules like fracture flow model and chemical species transport model which can be utilised to model flow and contaminant transport through fractured porous media.

Reference

[1] Dinesh, P., Kartha, S.A., Dutta, S. “Groundwater Flow Modeling of Kosi Alluvial Fan in Bihar State using GMS 3D Grid Approach”. National Conference on Water and its Sustainability in Mining and Other Environment. (WSME) Vision 2050, pp. 289-298, (2014).

Figures used in the abstract

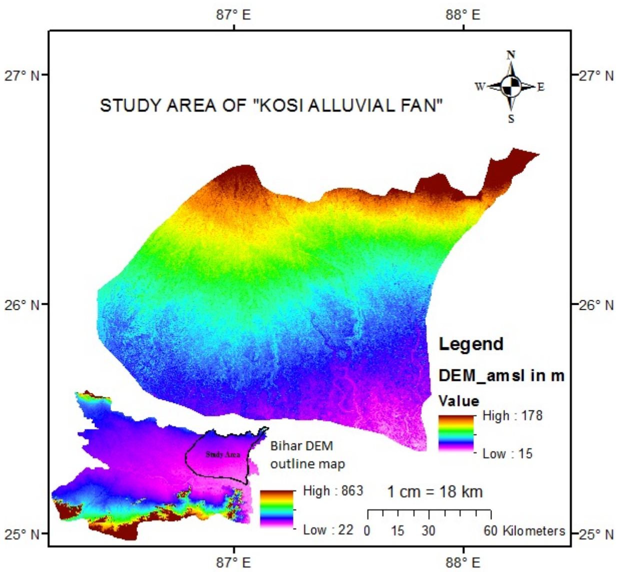

Figure 1: DEM of study area, Kosi Alluvial Fan, Bihar.

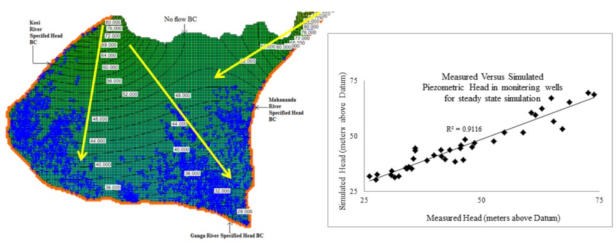

Figure 2: Steady state flow contours with direction and the observed Vs simulated head calibration graph [1].

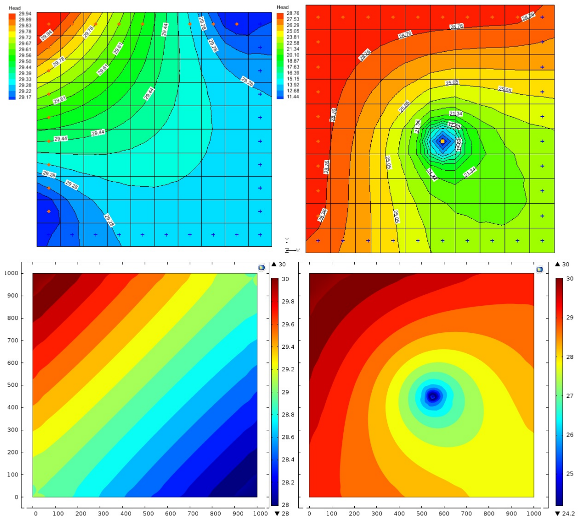

Figure 3: Comparison of simulation results at the confluencing point of two rivers having with/without pumping station using GMS and COMSOL Multiphysics software.

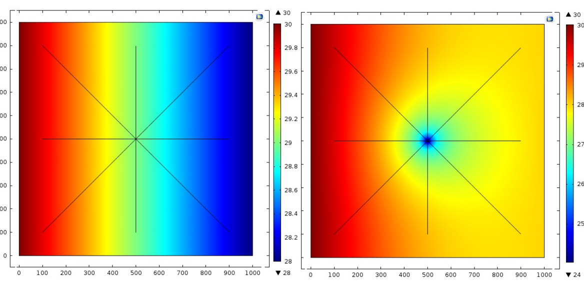

Figure 4: Multiple fractures in a hypothetical flow domain with/without pumping station using COMSOL Multiphysics.