Study on Groundwater Modeling of Aquifers Using Visual Modflow

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ABSTRACT- *Groundwater modeling is a tool that can help to analyze many groundwater problems. Numerical groundwater models are an important tool for the groundwater hydrologist. Nowadays, many computer programmes have been used in ground water modeling. One of them is software visual modflow that use a finite difference method to solve the equation. They can be used to simulate the behavior of complex aquifers including the effects of irregular boundaries, heterogeneity and different processes such as groundwater flow, and solute transport. This study aims to reveals that the suitability of modflow software under various hydrogeologic conditions. The hydrogeologic system may be disturbed by some natural or manmade processes. To predict the system behavior, visual modflow is the easy to use modeling environment for two dimensional and three dimensional groundwater flow and contaminant transport simulations.*

Keywords: *Groundwater, modeling, visual modflow, hydrogeologic system, groundwater flow, solute transport.*

1. INTRODUCTION

The use of aquifers is increasing as both a source of water supply and a medium for storing various hazardous wastes. As this usage expands, our knowledge of groundwater systems must also expand. Numerical groundwater modeling is a tool that can aid in studying groundwater problems and can help increase our understanding of groundwater systems. Numerical models have been extensively used for groundwater analysis, ground water quality and quantity stabilization and for groundwater management practices. Models are used for predictive studies to estimate future field behavior. In addition to this, models are useful for studying various types of flow behavior by examining hypothetical aquifer problems. Before attempting such studies, however, one must be familiar with ground water modeling concepts, model usage and modeling limitations.

1.1. Groundwater model

A model may be defined as a simplified version of a real-world system (here, a ground-water system) that approximately simulates the relevant excitation-response relations of the real-world system.

Different sets of simplifying assumptions will result in different models, each approximating the investigated ground-water system in a different way. The first step in the modeling process is the construction of a conceptual model consisting of a set of assumptions that verbally describe the system's composition, the transport processes that take place in it, the mechanisms that govern them, and the relevant medium properties. This is envisioned or approximated by the modeler for the purpose of constructing a model intended to provide information for a specific problem.

1.2 Numerical Models

Once the conceptual model is translated into a mathematical model in the form of governing equations, with associated boundary and initial conditions, a solution can be obtained by transforming it into a numerical model and writing a computer program (code) for solving it using a digital computer.

2. METHODOLOGY

2.1 Visual modflow

MODFLOW is a computer program originally developed by the U.S. Geological Survey that simulates three-dimensional groundwater flow using a finite difference technique for solution of the governing flow equations [Harbaugh et al., 2000]. MODFLOW solves both confined and unconfined flow equations in an irregularly shaped flow system to simulate the behavior of groundwater flow systems under several types of natural and artificial stresses. The flow region is subdivided into blocks in which the medium properties are assumed to be uniform.

In plan view the blocks are made from a grid of mutually perpendicular lines that may be variably spaced. Model layers can have varying thickness. A flow equation is written for each block, called a cell. Several solvers are provided for solving the resulting matrix problem. The user can choose the best solver for the particular problem. Flow-rate and cumulative-volume balances from each type of inflow and outflow are computed for each time step. Flow from external stresses, such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow through riverbeds, can be simulated.

Hydraulic conductivities or transmissivities for any layer may differ spatially and be anisotropic, and the storage coefficient may be heterogeneous. Specified head, specified flux, and head dependent flux boundaries can be simulated.

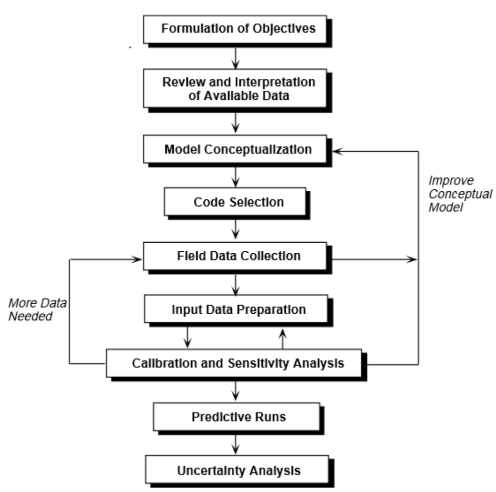

Figure 1 Flow of modeling process

Visual MODFLOW software package includes three main software and many support modules. MODFLOW software is used to calculate the volume, quality and distribution of groundwater flows. Function of MODPATH software is calculating the direction and speed of flow when it moves through aquifer system. MT3D software is used to calculate diffusion and transportation processes with chemical reaction of solutes in groundwater flow system.

2.2 Input data

American Society of Civil Engineers-Quality of Ground Water, focused the parameters needed for modeling are, (1)Rainfall data, (2)Lithology data, (3)Topography, (4)Groundwater level data, (5)Aquifer properties, (6)Pumping rate.

The input parameters required for the software are base map of study area, Specific yield, Specific storage, effective porosity, total porosity, horizontal and vertical hydraulic conductivities, thickness of soil etc.,

The input file formats to be given to a model are point data (XYZ) ASCII files (.TXT, .ASC, .DAT), MS Access Database files (.MDB), MS Excel files (.XLS), ESRI Point files (.SHP), USGS DEM files (.DEM), Surfer grid files (.GRD), ESRI grid files (.GRD) and Mapinfo grid files (.GRD).

2.3 Assigning initial and Boundary conditions

The boundary conditions allowed in Visual MODFLOW include constant-head, rivers, general head, drains, walls, recharge, evapotranspiration, constant concentration, (all are flow parameters for MODFLOW), and recharge concentration, evapotranspiration concentration, and point source concentration (all are concentration parameters for MT3Dxx/RT3D).

2.3 Output visualization

Prior to output visualization, customizing the run time settings for modflow, modpath and mt3d are necessary. When the engines are finished running , the model will be transferred to the output section, where the simulation results will be displayed.

The velocity vectors, pathlines, water table contours, concentration contours can be seen in 2D or 3D according to the selection.

2.4 Model Calibration

Every model must be calibrated before it can be used as a tool for predicting the behavior of a considered system. During the calibration phase, the initial estimates of model coefficients may be modified. The sensitivity analysis may be postponed until a numerical model and a code for its solution have been selected.

In this section objectives of the calibration or history matching, the adjusted parameters/coefficients, the criterion of the calibration (e.g., minimizing the difference between observed and predicted water levels), the available data, the model calibration runs, etc., should be described.

3. APPLICATION OF VISUAL MODFLOW

1. Numerical modeling package, Visual MODFLOW (Version 4.2) was used to predict fate and transport of phosphorous in landfill of Seri Pataling. It might be helpful to control pollution in Landfill [1].

2. Visual MODFLOW 3.0 groundwater modeling package is utilized to quantify groundwater – surface water interaction. Visual MODFLOW 3.0 package is an integrated modeling environment for applications in three – dimensional groundwater flow and contaminant transport simulations based on the finite-difference method.

3. The groundwater flow modeling for an unconfined coastal aquifer surrounded by saline water bodies plays a significant role in providing the information on direction and magnitude of groundwater flow with respect to seasons and location. The modeling package MODFLOW was employed in the Visual MODFLOW Pro 2009.1 was applied to simulate the steady state run for Kalpakkam coastal aquifer [4].

4. It can be suitable for seawater intrusion modeling environment based on chloride concentration or Electrical conductivity (EC).

4. RESULTS AND DISCUSSION

Advantages of MODFLOW include numerous facilities for data preparation, the modular structure that allows it to be easily modified to adapt the code for a particular application, great flexibility in handling a wide range of complexity, easy exchange of data in standard form, extended worldwide experience, continuous development and availability of the source code. In addition to simulating groundwater flow, the scope of MODFLOW has been expanded to incorporate related capabilities such as solute transport and parameter estimation.

5. CONCLUSION

From the above discussion, Visual MODFLOW software is suitable (1) To simulate and predict the aquifer conditions and to represent the natural groundwater flow in the environment, (2) To forecast the outcome of future groundwater behavior, (3) To simulate hydraulic heads and ground water flow rates within and across the boundaries of the system, (4) To simulate the concentrations of substance dissolved in ground water.

REFERENCES

[1] Seyed Reza Saghravani and Sa'ari Mustapha, Prediction of Contamination Migration in an Unconfined Aquifer with Visual MODFLOW: A Case Study World Applied Sciences Journal 14 (7): 1102-1106, 2011 ISSN 1818-4952 © IDOSI Publications, 2011

[2] G Saner, W. Barclay Shoemaker Important Observations and Parameters for a Salt Water Intrusion Model, Vol. 42 No. 6—GROUND WATER—November–December 2004 (pages 829–840)

[3] Jemaneh Shibru Wake, *Groundwater – Surface water interaction modeling using visual MODFLOW and GIS,* June 2008.

[4]R. Kaviyarasan, H. Seshadri, P. Sasidhar, Assessment of groundwater flow model for an unconfined coastal aquifer, International Journal of Innovative Research in Science, Engineering and Technology Volume 2, Special Issue 1, December *2013*, ISSN (Online) : 2319 – 8753 ISSN (Print) : 2347 – 6710

[5] Helena lind, Groundwater Flow Model of the Western Part of the Estonian Oil Shale Deposit. ISSN 1406-474X ISBN 978-9949-23-003-7

[6] Marika Palamer Rivera, A numerical groundwater model for Urania (SP, Brazil) Luleal University thesis, ISSN 1406-474X ISBN 978-9949-23-003-7

[7]Seyed reza saghravan, Prediction of phosphorus concentration in an unconfined aquifer using visual modflow, University Putra publication Malaysia, May 2009.

[8]Needhidasan S & Manoj Nallanathel, Application of Visual modflow and gis in groundwater modeling, International Journal of Civil Engineering (IJCE) ISSN 2278-9987 Vol. 2, Issue 3, July 2013, 41-50

[9]Iin Lestari, Suprihanto Notodarmojo, Study of Visual modflow application for seawater intrusion modelling in phreatic aquifer

[10]Guiger, Nilson and Franz, Thomas, User's Manual for Visual Modflow, Waterloo Hydrogeologic, Canada.

[11] http://www.sciencedirect.com/modflow

[12] http://www.google.com/Modflow

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