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Evaluation of groundwater modelling

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Abstract

The study deals with groundwater technique involving flow hydrodynamics and water quality mass transport. Modeling is a very wide term as used and applied in earth sciences, many studies have conceptual models, hydrogeological models, mathematical models, analytical models, numerical models, stochastic models and deterministic models. There are marked differences among these models but also many similarities depending on their use and dimensions of applications. The study treated flow-hydrodynamics and Water quality-mass transport. The study deals with an evaluation of a conceptual model in hydrology which is the pictorial representation of the groundwater flow explained in the form of a block diagram. The observations of the research implication have been that qualitative interpretation of data and information of a site are conceptualized.

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Introduction

Many studies have been carried by researchers Pricheck Lunnquist 1971 studies digital computer technique for groundwater, while M/C Donald Harhagh 1984 worked on moular 3 dimension finite difference ground water flow water Tress Cott et al 1976, Wavy – Anderson 1982 worked on final difference model for aquifer simulation, ground water modeling finite difference and finite dimension method.

The development of groundwater modeling in the findings of Alfonso Rivera 2010, indicated hydrogeology modeling enquires numerical methods to both a suitable representation of the subsurface and an adequate base for the simulation of flow and transport processes required for environmental studies (water resources, climate change). As a prerequisite to building a (numerical) geological model, it is necessary first to generate a conceptual model. This conceptual model combines data and knowledge from various disciplines concerning geometry, geology, physical parameters and processes of interest. This process however should be iterative; the conceptual model should be updated as additional environmental, geologic and hydrogeologic studies, as well as simulations with the origin model, provide new data and new understanding of the groundwater flow system. The flow of groundwater through rock is normally modeled using one of two types of models. If the length scale of interest is large compared with the scale of heterogeneities, such as fracture length, then an equivalent porous medium (EPM) approximation can be use. In this case, properties such as hydraulic conductivity are average over appropriate rock volumes. This is the most common approach still used systematically used for groundwater resources research; see section below. This is an area where groundwater modelers need additional support from the geological modelers to decide on whether the conceptual models of those aquifers are right and acceptable.

For fractured rock, the structure of the rock is often heterogeneous on the scale of interest. For instance, the dominant medium for flow may be a set of large discrete fractures. In this case, discrete fractured network (DFN) model can be used to explicitly represent each fracture. However, it is usually impossible to provide an exact specification for the fractured network in cases of practical interest (i.e., water resources at regional scale) because of the complexity of the rock structure and its obvious inaccessibility. Instead, the structure of the rock is described in term of the statistic of the fracture sets, such as the fracture density and orientation. A stochastic approach is then used to generate a number of independent realizations of the fracture system. The hydrodynamics to solve for in this stage may include any variable of the flow and transport systems, pressure, concentration, heat, compaction, etc. (Heinzer and Williams 2005). The aim of this study is to evaluate the groundwater modeling systems analysis study used to indicate the fractured rocks.

Material and Method

Groundwater flow is reasonably well defined for aquifer (rock) structures. However, water flow is extremely complex in the unsaturated soil layer above the rocks. This zone of subsoil is sometimes called the unsaturated zone as it is subject to wetting and drying, depending on many parameters not least of all rainfall and in finable for aquifer but is complex in the unsaturated zone. This section will briefly examine modeling with respect to: flow-hydrodynamics and water quality-mass transport (Fig. 1).

The types of current and future environmental (groundwater) model are grouped in four broad categories. Bedient Hubert (1988) studied on hydrology and flood plain while Heinzer Williams (2005) worked on object based hydrodynamics of ground water. Themen et al 2004) worked on hydrogeoshper.

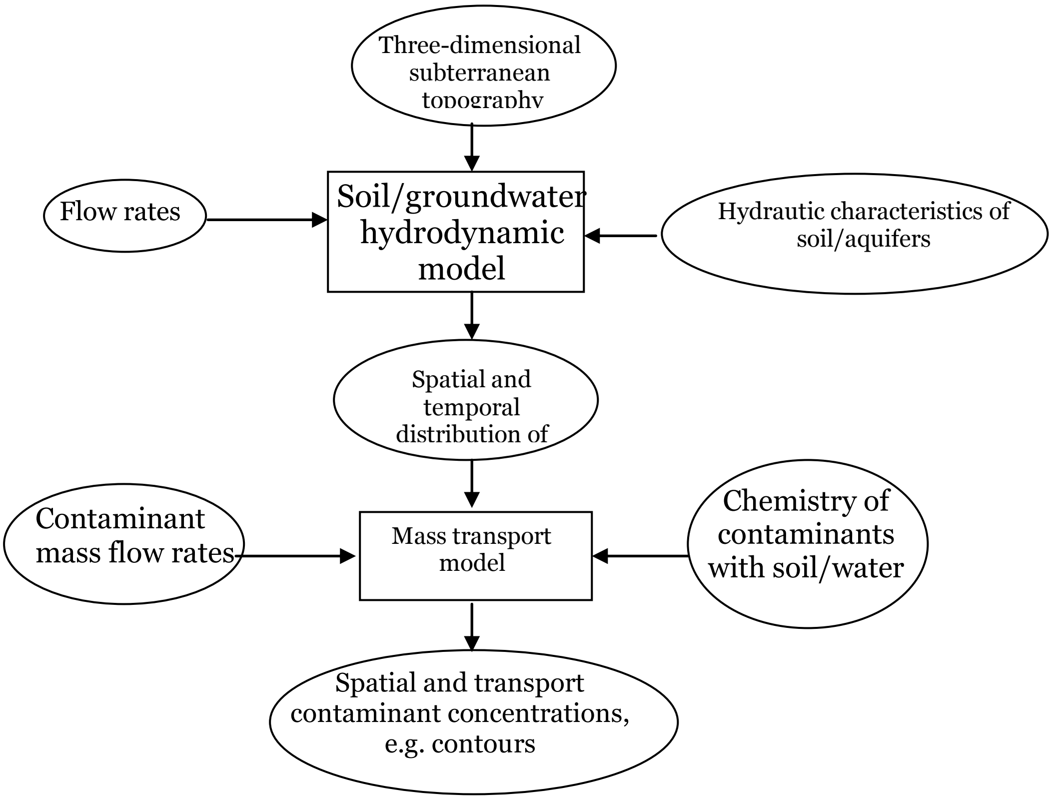

Fig. 1. Flow and transport model in the subsoil/aquifer.

Flow modelling in groundwater

For flow modeling, the Laplace equation combines the continuity equation and Darcy's law into second order partial differential equation as follows:

$$\frac{\partial}{\partial x}\left(K_x \frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_y \frac{\partial h}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z \frac{\partial h}{\partial z}\right) = S \frac{\partial h}{\partial t} - R(x,y,z)$$

where K_x, K_y, K_z = the hydraulic conductivity in the x,y,z direction

h = water head

S = storage coefficient

R = recharge

For the two-dimensional case with steady flow and no recharge this equation reduces to

$$\frac{\partial}{\partial x}\left(K_x \frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial z}\left(K_x \frac{\partial h}{\partial z}\right) = 0$$

Typically $K_y = k_x$ in the horizontal plane.

If $k_x = k_z$ then this reduces to

$$\frac{\partial \partial h}{\partial x^2} + \frac{\partial^2 h}{\partial z^2} = 0$$

Finite difference model commonly used in he past have been those developed by Prickett and Lonnquist (1971) and Trescott et al. (1976). Both of these models solved a form of the unsteady flow equation which allowed for heterogeneous and anisotropic soils/aquifers. The equation solved by them was

$$\frac{\partial}{\partial x}\left(K_x \frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial z}\left(K_z \frac{\partial h}{\partial z}\right) = S \frac{\partial h}{\partial t} - R(x,z,t)$$

McDonald and Harbaugh (1984) extended this model to that of three dimensions. The reader is referred to Wang and Anderson (1982), Bedient and Hubert (1988) for further details and applications. The type of current table is categories into four groups as is shown in Table 1.

Contaminant transport

Extensive modeling effort has been applied to the mass transport of contaminants in soil/groundwater over the past two decades. The mechanism of pollutant transport depends on hydraulic conductivity of the soil/aquifer. If the hydraulic conductivity is very low, as in some aquifers and clays, then the transport mechanism may he primarily by diffusion. For high conductivity, advection is the dominant transport mechanism. The problem of transport becomes more complex if the contaminant is a reactive chemical. In such a situation, chemical reaction rates and even microbial rates may need to be considered. In the case of bioremediation of contaminated soils, using specific microbes the reaction rates for microbes are significant and arc considered in the B1oPHJMR 11 model by Bedient and Rifai (1993).

The one-dimensional advection-dispersion equation derived in this chapter applies also to the movement of a contaminant in the subsurface environment;

$$\frac{\partial C}{\partial t} = \frac{D\partial^2 C}{\partial t^2} - U\frac{\partial C}{\partial t}$$

Where C= concentration of non-reaction contaminating. g/m^3

D= hydrodynamic dispersion

U= average fluid velocity

And $\underline{D\partial^2 C}$ = Fick's second law for diffusive ∂_x^2

And $u\partial\underline{C}$ = the mass flow or convective adjective flow

∂x

D has many definitions, particularly in the context of solute movement in the ground:

D= Do˥ + xv

Where Do= free solution diffusion coefficient

˥ = tortuosity factor

X = dispersive parameter

V = flow velocity

The task is to solve adjective diffusion, for the above boundary condition. The ogata and Bank (1961) solution for this is

$$\frac{C}{Co} = \frac{1}{2}\left[\text{erfc}\left(\frac{x-vt}{\sqrt{4Dt}}\right) + \exp\left(\frac{vx}{D}\right)\text{erf}\left(\frac{x-vt}{\sqrt{4Dt}}\right)\right]$$

Where Co = the initial contaminant concentration, g/m3

C = the concentration at any distance x > 0

V = average velocity, m/s

D = dispersion coefficient

Erfc= complementary error function

Table 1. Types of Environmental Water Models.

Category	Current state	Application
Separated models ▸ Meteorological ▸ Hydrological ▸ Hydrogeological	▸ High uncertainties ▸ Mid uncertainties ▸ Mid uncertainties	▸ limate predictions ▸ Surface water resources ▸ Groundwater resources and contaminant
Coupled models ▸ Meteorological hydrological ▸ Hydrological ▸ Hydrogeological	▸ High uncertainties ▸ Mid uncertainties	▸ Watershed analysis and IWRM ▸ IWRM and Climate Change
Semi-integrated models ▸ Hydrodynamic ▸ Watershed dynamics ▸ Watershed management	On-going research still many uncertainties	▸ Resource management ▸ Watershed without groundwater, and without management ▸ Watershed with groundwater, without management.
Fully-integrated models ▸ Coupled meteorological-hydrological -hydrogeological	Category of the future, still containing high uncertainties	For climate change scenarios coupling climate, surface water and groundwater (i.e., HydroGeoShpere, Therrien, *et al.*, 2004)

Conclusion

The evaluation of groundwater modeling is analyzed. The study deals with the flow-hydrodynamics and Water quality-mass transport.

References

Pricket F.A and Lunnquist C J 1971 Selected digital computer technique for groundwater Resource Evaluation Illinois State water survey Bullet 55 p.c.

Tres Cott. 1976. Fint difference models for Aquifer simulation in two Dimensions with result of numerical experiment USGS Technique of water resource Investigations Washington.

Donald M, Harhaugh. 1984 Modular three Dimension Finite Difference groundwater Flow model Virginia.

Wavy HF, Anderson. 1982. introduction to groundwater modeling finite difference and finite elements methods W.H. Free man company San Francisco to California.

Bedient PH, Hubert WC. 1988. Hydrology and flood plain Analysis Anderson – Westley Publishing, Reading, Massachutess.

Heinzer T, Williams D. 2005. Applied Research in Arc objects-based Hydrodynamics Analysis.

Therrien R, Miclaren RG, Sudicky EA, Panday SM. 2004. HydroGeoSphere: A Three-dimensional Numerical Models Describing Fully Integrated Subsurface and Surface flow and solute transport, Manual (Draft), Hydrogeologic Inc, Herndon, VA.