

Numerical Groundwater Contaminant Transport Modeling With Spreadsheets

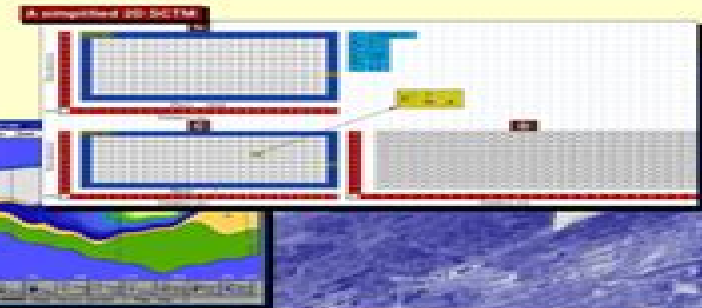
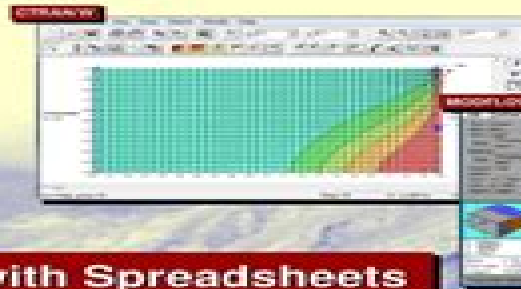
Ali Shokri

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Aims of Using Spreadsheets

There are two main methods for numerical contaminant transport modeling using general commercial software (the second). One is CTRANW and the other is spreadsheets such as MATLAB or Excel Basic. Both methods have advantages. Commercial software has been developed with a view to solving governing equations and therefore they are not subject to some particular errors. On the other hand, using spreadsheets needs a high level of knowledge of computer programming. This paper discusses the Spreadsheets CTRANW and the second method (SCTM) which is both flexible, user-friendly, and also helpful for educational purposes.



Methods of Modeling with Spreadsheets

The basis of a spreadsheet-based numerical groundwater model is that each cell represents an equal node in a finite difference grid. The model is developed using spreadsheets and incorporates the contaminant transport governing equation, generally known as the advection-dispersion equation (ADE).
 Co-ordination (X,Y,Z)
 Co-ordinate velocity (U,V,W)
 Co-ordinate dispersion coefficient (D_x, D_y, D_z)



Example1: Ogata 1D analytical solution no adsorption and decay

Comparison of SCTM with CTRANW and Analytical Solution



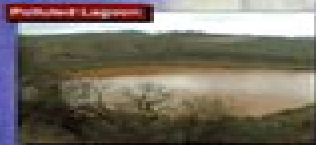
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This paper introduces the mathematical framework and techniques for modeling groundwater contaminant transport using spreadsheets. The model is developed using spreadsheets and incorporates the contaminant transport governing equation, generally known as the advection-dispersion equation (ADE). The model is developed using spreadsheets and incorporates the contaminant transport governing equation, generally known as the advection-dispersion equation (ADE). The model is developed using spreadsheets and incorporates the contaminant transport governing equation, generally known as the advection-dispersion equation (ADE).

$$C = \frac{Q}{4\pi T} \left(\exp\left(-\frac{r^2}{4Dt}\right) + \exp\left(-\frac{r^2}{4Dt}\right) \right)$$

Where:
 C = contaminant concentration at the source boundary (mg/L)
 Q = injected mass (kg)
 T = transmissivity (m²/s)
 D = diffusion coefficient (m²/s)
 r = radial distance from the source boundary (m)
 t = time (s)

A similar comparison is made with respect to the velocity field. The model is developed using spreadsheets and incorporates the contaminant transport governing equation, generally known as the advection-dispersion equation (ADE). The model is developed using spreadsheets and incorporates the contaminant transport governing equation, generally known as the advection-dispersion equation (ADE).



Example2: 2D numerical model of contaminant transport polluted lagoon

A sample of result of SCTM



Results

The SCTM model has the required accuracy despite its simplicity. Some of advantages of model are being user friendly, giving a graphical presentation to user, intuitive process for changing data in each node, quick access to all output data. These advantages make SCTM to a suitable method for professional and educational aims. However this method just can be used to make reference calculations and it is not suitable for the more complex models.

Applied Contaminant Transport Modeling

Hossein Ghadiri, Calvin Rose



Applied Contaminant Transport Modeling:

Applied Contaminant Transport Modeling Chunmiao Zheng, Gordon D. Bennett, 1995-08-07 Applied Contaminant Transport Modeling Theory and Practice Chunmiao Zheng and Gordon D Bennett The design of remedial systems for groundwater contamination requires a thorough understanding of how various interacting processes advection dispersion and chemical reactions influence the movement and fate of contaminants Solute transport simulation provides an ideal vehicle to synthesize these controlling processes evaluate their interactions and test the effectiveness of remedial measures Applied Contaminant Transport Modeling is the first complete resource designed to provide clear coverage of the basic principles of solute transport simulation including the theory behind the most common numerical techniques for solving transport equations and step by step guidance on the development and use of field scale models Written by two experts with extensive practical experience in the field Applied Contaminant Transport Modeling clearly explains Factors controlling the transport and fate of solutes in the subsurface including advective and dispersive transport and chemical reaction and the equations governing these processes Development of mathematical models of solute transport regimes and representative analytical solutions to the transport equation Particle tracking as a practical tool for solving many types of field problems Development of Eulerian Lagrangian methods for solving advection dispersion reaction equations Step by step development and application of solute transport models emphasizing problem formulation model setup parameter selection calibration and sensitivity analysis Sources of uncertainty in transport simulation and methods of evaluating and managing uncertainty Applied Contaminant Transport Modeling presents detailed case histories illustrating how hydrologists geologists chemists and environmental engineers apply transport models in real life situations including landfills hazardous waste sites and contaminated aquifers An optional diskette designed to accompany the text provides software to help the reader explore the concepts and techniques presented in the text and gain hands on experience in transport simulation Driven by growing concern over groundwater quality and the rapid dissemination of computer technology solute transport simulation has become an essential means of evaluating and solving groundwater contamination and remediation problems Applied Contaminant Transport Modeling provides you with the tools to master this significant field of study **Applied**

Contaminant Transport Modeling Chunmiao Zheng, Gordon D. Bennett, 1995-01-01 This resource is designed to provide clear coverage of the basic principles of solute transport simulation including the theory behind the most common numerical techniques for solving transport equations and step by step guidance on the development and use of field scale models It presents detailed case histories illustrating how hydrologists geologists chemists and environmental engineers apply transport models in real life situations including landfills hazardous waste sites and contaminated aquifers *Applied Contaminant Transport Modeling: Theory and Practice* Zheng, C & Bennett, G.D., 1995 [Applied Contaminant Transport Modeling](#) Chunmiao Zheng, Gordon D. Bennett, 2002-02-05 The challenges facing groundwater scientists and engineers today

demand expertise in a wide variety of disciplines geology hydraulics geochemistry geophysics and biology As the number of the subdisciplines has increased and as each has become more complex and quantitative the problem of integrating their concepts and contributions into a coherent overall interpretation has become progressively more difficult To an increasing degree transport simulation has emerged as an answer to this problem and the transport model has become a vehicle for integrating the vast amount of field data from a variety of sources and for understanding the relationship of various physical chemical and biological processes Applied Contaminant Transport Modeling is the first resource designed to provide coverage of the discipline s basic principles including the theories behind solute transport in groundwater common numerical techniques for solving transport equations and step by step guidance on the development and use of field scale modeling The Second Edition incorporates recent advances in contaminant transport theory and simulation techniques adding the following to the original text An expanded discussion of the role of aquifer heterogeneity in controlling solute transport A new section on the dual domain mass transfer approach as an alternative to the classical advection dispersion model Additional chemical processes and reactions in the discussion of reactive transport A discussion of the TVD total variation diminishing approach to transport solution An entirely new Part III containing two chapters on simulation of flow and transport under variable water density and under variable saturation respectively and a third chapter on the use of the simulation optimization approach in remediation system design Applied Contaminant Transport Modeling Second Edition remains the premier reference for practicing hydrogeologists environmental scientists engineers and graduate students in the field In 1998 in recognition of their work on the first edition the authors were honored with the John Hem Excellence in Science and Engineering Award of the National Ground Water Association

Modeling Groundwater Flow and Contaminant

Transport Jacob Bear,Alexander H.-D. Cheng,2010-01-18 In many parts of the world groundwater resources are under increasing threat from growing demands wasteful use and contamination To face the challenge good planning and management practices are needed A key to the management of groundwater is the ability to model the movement of fluids and contaminants in the subsurface The purpose of this book is to construct conceptual and mathematical models that can provide the information required for making decisions associated with the management of groundwater resources and the remediation of contaminated aquifers The basic approach of this book is to accurately describe the underlying physics of groundwater flow and solute transport in heterogeneous porous media starting at the microscopic level and to rigorously derive their mathematical representation at the macroscopic levels The well posed macroscopic mathematical models are formulated for saturated single phase flow as well as for unsaturated and multiphase flow and for the transport of single and multiple chemical species Numerical models are presented and computer codes are reviewed as tools for solving the models The problem of seawater intrusion into coastal aquifers is examined and modeled The issues of uncertainty in model input data and output are addressed The book concludes with a chapter on the management of groundwater resources Although

one of the main objectives of this book is to construct mathematical models the amount of mathematics required is kept minimal

Modelling of Pollutants in Complex Environmental Systems Grady Hanrahan, 2010 Environmental modelling has enjoyed a long tradition but there is a defined need to continually address both the power and the limitations of such models as well as their quantitative assessment This book showcases modern environmental modelling methods the basic theory behind them and their incorporation into complex environmental investigations It highlights advanced computing technologies and how they have led to unprecedented and adaptive modelling simulation and decision support tools to study complex environmental systems and how they can be applied to current environmental concerns This volume is essential reading for researchers in academia industry and government related bodies who have a vested interest in all aspects of environmental modelling Features include A range of modern environmental modelling techniques are described by experts from around the world including the USA Canada Australia Europe and Thailand many examples from air water soil sediment and biological matrices are covered in detail throughout the book key chapters are included on modelling uncertainty and sensitivity analysis and a selection of figures are provided in full colour to enable greater comprehension of the topics discussed

Modeling Chemical Transport in Soils Hossein Ghadiri, Calvin Rose, 1992-09-23 Modeling Chemical Transport in Soils Natural and Applied Contaminants provides a comprehensive discussion of mathematical models used to anticipate and predict the consequences and fate of natural and applied chemicals The book evaluates the strengths weaknesses and possibilities for application of numerous models used throughout the world It examines the theoretical support and need for experimental calibration for each model The book also reviews world literature to discuss such topics as the movement of sorbed chemicals by soil erosion the movement of reactive and nonreactive chemicals in the subsurface and groundwater and salt transport in the landscape Modeling Chemical Transport in Soils Natural and Applied Contaminants is an important volume for environmental scientists agricultural engineers regulatory personnel farm managers consultants and the chemical industry

Practical Handbook of Soil, Vadose Zone, and Ground-Water Contamination J. Russell Boulding, Jon S. Ginn, 2016-04-19 A synthesis of years of interdisciplinary research and practice the second edition of this bestseller continues to serve as a primary resource for information on the assessment remediation and control of contamination on and below the ground surface Practical Handbook of Soil Vadose Zone and Ground Water Contamination Assessment Prev

Applied Flow and Solute Transport Modeling in Aquifers Vedat Batu, 2005-07-12 Over recent years important contributions on the topic of solving various aquifer problems have been presented in numerous papers and reports The scattered and wide ranging nature of this information has made finding solutions and best practices difficult Comprehensive and self contained Applied Flow and Solute Transport Modeling in Aquifers compiles the scattered literature on the topic into a single source reference of the most up to date information in the field Based on Dr Batu s 20 years of practical experience tackling aquifer problems in a myriad of settings the book addresses essentially all currently applied aquifer flow and

contaminant transport solutions combines theory with practical applications covers both analytical and numerical solutions and includes solutions to real world contaminant transport modeling scenarios Batu approaches the subject from the practicing consultant's point of view and elucidates the difficulties real world professionals have faced in solving aquifer flow and contamination problems The author simplifies the necessary theoretical background as much as possible and provides all derivational details of the theoretical background as worked examples He uses this method to explore how the derivations were generated for those who need to know while allowing others to easily skip them and still benefit and learn from the practical applications of the mathematical approaches Containing 51 tables and 323 figures the book covers both the breadth and the depth of currently applied aquifer flow and contaminant transport modeling solutions **Rapid, Reproducible, and Robust Environmental Modeling for Decision Support: Worked Examples and Open-Source Software Tools**

Jeremy White, Michael Fienen, Catherine Moore, Anneli Guthke, 2023-10-11 **Environmental Geology** Klaus

Knödel, Gerhard Lange, Hans-Jürgen Voigt, 2007-12-31 This illustrated handbook describes a broad spectrum of methods in the fields of remote sensing geophysics geology hydrogeology geochemistry and microbiology designed to investigate landfill mining and industrial sites The descriptions provide information about the principle of the methods applications and fundamentals This handbook also deals with the stepwise procedure for investigating sites and common problems faced in efficient implementation of field operations *FEFLOW* Hans-Jörg G. Diersch, 2013-11-22 *FEFLOW* is an acronym of Finite Element subsurface FLOW simulation system and solves the governing flow mass and heat transport equations in porous and fractured media by a multidimensional finite element method for complex geometric and parametric situations including variable fluid density variable saturation free surface's multispecies reaction kinetics non isothermal flow and multidiffusive effects *FEFLOW* comprises theoretical work modeling experiences and simulation practice from a period of about 40 years In this light the main objective of the present book is to share this achieved level of modeling with all required details of the physical and numerical background with the reader The book is intended to put advanced theoretical and numerical methods into the hands of modeling practitioners and scientists It starts with a more general theory for all relevant flow and transport phenomena on the basis of the continuum approach systematically develops the basic framework for important classes of problems e.g. multiphase multispecies non isothermal flow and transport phenomena discrete features aquifer averaged equations geothermal processes introduces finite element techniques for solving the basic balance equations in detail discusses advanced numerical algorithms for the resulting nonlinear and linear problems and completes with a number of benchmarks applications and exercises to illustrate the different types of problems and ways to tackle them successfully e.g. flow and seepage problems unsaturated saturated flow advective diffusion transport saltwater intrusion geothermal and thermohaline flow **Analytical Modeling of Solute Transport in Groundwater** Mark Goltz, Junqi Huang, 2017-02-21

Teaches using simple analytical models how physical chemical and biological processes in the subsurface affect contaminant

transport Uses simple analytical models to demonstrate the impact of subsurface processes on the fate and transport of groundwater contaminants Includes downloadable modeling tool that provides easily understood graphical output for over thirty models Modeling tool and book are integrated to facilitate reader understanding Collects analytical solutions from many sources into a single volume and for the interested reader shows how these solutions are derived from the governing model equations

Coupled Flow and Contaminant Transport Modeling in Large Watersheds Orhan Gunduz, 2004 A hybrid surface subsurface flow and transport model is developed that blends distributed parameter models with simpler lumped parameter models The hybrid model solves the channel flow and saturated groundwater flow domains in continuous time using fully distributed physically based formulations This system is supplemented with the overland flow and unsaturated groundwater flow that uses lumped parameter descriptions in discrete time In the proposed model a one dimensional channel flow model is dynamically coupled with a two dimensional vertically averaged groundwater flow model along the river bed As an alternative to the commonly applied iterative solution technique a so called simultaneous solution procedure is developed to provide a better understanding to the coupled flow problem This new methodology is based on the principle of solving the two flow domains within a single matrix structure in a simultaneous manner In addition to the flow model a coupled contaminant transport model is also developed to simulate the migration of contaminants between surface and subsurface domains The contaminant transport model dynamically couples a one dimensional channel transport model with a two dimensional vertically averaged groundwater transport model The coupling is performed at the river bed interface via advective and dispersive transport mechanisms A modified extension of the proposed simultaneous solution procedure is also implemented to solve the coupled contaminant transport problem The dynamic coupling provides the much needed understanding for the continuity of contaminants in strongly interacting surface subsurface systems such as a river and an unconfined aquifer The coupled flow and transport models are applied to the lower Altamaha watershed in southern Georgia The flow model is used to perform simulations of hydrologic and hydraulic conditions along the river and in the dynamically linked surficial aquifer The model predicted the flood patterns including the magnitude of peaks and their arrival times with accuracy Under the given flow conditions the transport model is then implemented to test alternative contaminant transport patterns both in the river and within the aquifer It has been found that the channel network would serve as a conduit for rapid transport of contaminants within the aquifer to large distances in small time frames

Reactive Transport in Porous Media Peter C. Lichtner, Carl I. Steefel, Eric H. Oelkers, 2018-12-17 Volume 34 of Reviews in Mineralogy focuses on methods to describe the extent and consequences of reactive flow and transport in natural subsurface systems Since the field of reactive transport within the Earth Sciences is a highly multidisciplinary area of research including geochemistry geology physics chemistry hydrology and engineering this book is an attempt to some extent bridge the gap between these different disciplines This volume contains the contributions presented at a short course held in Golden Colorado October 25 27 1996 in

conjunction with the Mineralogical Society of America's MSA Annual Meeting with the Geological Society of America in Denver Colorado

Integrated Environmental Modeling Anu Ramaswami, Jana B. Milford, Mitchell J. Small, 2005-04-15
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Systems Analysis for Sustainable Engineering: Theory and Applications Ni-Bin Chang, 2010-10-22
 IMPLEMENT SYSTEMS ANALYSIS TOOLS IN SUSTAINABLE ENGINEERING
 Featuring a multidisciplinary approach Systems Analysis for Sustainable Engineering Theory and Applications provides a proven framework for applying systems analysis tools to account for environmental impacts energy efficiency cost effectiveness socioeconomic implications and ecosystem health in engineering solutions This pioneering work addresses the increased levels of sophistication embedded in many complex large scale infrastructure systems and their interactions with the natural environment After a detailed overview of sustainable systems engineering the book covers mathematical theories of systems analysis environmental resources management industrial ecology and sustainable design Real world examples highlight the methodologies presented in this authoritative resource
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