Preface

We have attempted to explain the concepts which have been used and developed to model the stochastic dynamics of natural and biological systems. While the theory of stochastic differential equations and stochastic processes provide an attractive framework with an intuitive appeal to many problems with naturally induced variations, the solutions to such models are an active area of research, which is in its infancy. Therefore, this book should provide a large number of areas to research further. We also tried to explain the ideas in an intuitive and descriptive manner without being mathematically rigorous. Hopefully this will help the understanding of the concepts discussed here.

This book is intended for the scientists, engineers and research students who are interested in pursuing a stochastic dynamical approach in modeling natural and biological systems. Often in similar books explaining the applications of stochastic processes and differential equations, rigorous mathematical approaches have been taken without emphasizing the concepts in an intuitive manner. We attempt to present some of the concepts encountered in the theory of stochastic differential equations within the context of the problem of modeling solute transport in porous media. We believe that the problem of modeling transport processes in porous media is a natural setting to discuss applications of stochastic dynamics. We hope that the engineering and science students and researchers would be interested in this promising area of mathematics as well as in the problems we try to discuss here.

We explain the research problems associated with solute flow in porous media in Chapter 1 and we have argued for more sophisticated mathematical and computational frameworks for the problems encountered in natural systems with the presence of system noise. In Chapter 2, we introduce stochastic calculus in a relatively simple setting, and we illustrate the behavior of stochastic models through computer simulation in Chapter 3. Chapter 4 is devoted to a limited number of methods for solving stochastic differential equations. In Chapter 5, we discuss the potential theory as applied to stochastic systems and Chapter 6 is devoted to the discussion of modeling of fluid velocity as a fundamental stochastic variable. We apply potential theory to model solute dispersion in Chapter 7 in an attempt to model the effects of velocity variations on the downstream probability distributions of concentration plumes. In Chapter 8 we develop a mathematical and computational framework to model solute transport in saturated porous media without resorting to the Fickian type assumptions as in the advection-dispersion equation. The behavior of this model is explored using the computational experiments and experimental data to a limited extent. In Chapter 9, we introduce an efficient method to solve the eigenvalue problem associated with the modeling framework when the correlation length is variable. A stochastic inverse method that could be useful to estimate parameters in stochastic partial differential equations is described in Chapter 10. Reader should find many directions to explore further, and we have included a reasonable number of references at the end.

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