4. Transport in Porous Media

4.1 Introduction

4.1.1 Solute Transport

Groundwater flow simulation requires

(1)

(2)

(3)

Groundwater flow simulation + Solute movement

Complexity increases by an order of magnitude due to

(1) Reactions must be represented in the governing equation

(2) All parameters quantifying reactions must be established

(3) For greater difficulty of matching the computational scheme

Complexity increase by additional order of magnitude due to

(1)

(2)

4.1.2 A Historical Perspective

1985 Darcy, H. (1985) Les Publiques de la Ville De Dijon, Dalmont, Paris

Darcy's experimental results were not applied to groundwater until much later.

1899 Slichter recognized that advective calculation alone could not fully describe solute transport.

1930s The basis for much of modern groundwater hydrology has been provided. Also, the general theory of flow through porous media was advanced in the field of petroleum engineering concurrently.

Solute transport was considered only in vary limited way; the problem in which it

arose most frequently was that of seawater.

1950s Statistical theories of hydrodynamic dispersion were developed. Simulations utilized electric analog models, in form of passive-capacitance networks. Intense concerns began to develop over the fate of radioactive materials in the subsurface.

1960s The theory of advective-dispersive transport continued to develop. A number of analytical solutions were developed. Early applications of numerical simulations were published.

1970s The beginning of rapid development due to (1) Intensified interest in groundwater quality by stringent remediation and protection standards and (2) the rapid development of computer technology. The emphasis shifted to anthropogenic contaminants. 3-D flow models and finite-element methods in solute transport, and parameter estimation techniques in flow simulation were introduced. Filed-scale tracer tests were executed to evaluate the effect of macroscopic heterogeneity on the dispersion theory.

1980s Transport model with equilibrium controlled reactions, such as sorption of organic compounds and was provided (e.g., Sorption of organic compounds and linear sorption was incorporated in practical simulation). Biodegradation of organic chemicals in the subsurface was extensively investigated. Coupling of transport simulation with both equilibrium-controlled and kinetic reactions was provided.

Since 1980s Solute transport in fractured media and in multiphase flow systems have been addressed.