HWR 516, Hydrological Transport Process (Fall 2003).
Lecturer: T.-C. Jim Yeh
Time: Tue and Thu, 2:00 PM to 3:15 PM
Prerequisites: Either HWR 535, SWE 605 or HWR 503 or equivalent. Knowledge of differential equations is a must; some computer programming skills are needed; and working knowledge of numerical methods (or HWR 504) will be a plus.

Course Description:

The purpose of the course is to provide a fundamental understanding of the physical processes and principles that govern energy and solute transport in streams, and variably saturated porous media from microscopic to field scales. The course examines a variety of conceptual and mathematical models that quantify these transport processes, and various techniques commonly used for estimating parameters for solute transport. More importantly, it introduces new techniques and approaches for monitoring, characterization, and forecast solute transport processes in the field.

Specifically, the class begins with lump parameter models that employ the "well-mixed" assumption for fluids, chemicals, and energy in lakes, rivers, aquifers, and the vadose zone. To avoid the well-mixed assumption and to increase the spatial resolution of our description of the transport processes, the class subsequently introduces the concepts of molecular diffusion, Brownian motion, Fick's law, and advection-diffusion process. Both analytical and numerical solutions to the advection-diffusion equations are covered for various boundary and initial conditions.

Next, G.I. Taylor's theory for solute transport through pipes is visited, including the analysis of shear flow dispersion phenomena. The convection-dispersion equation and the concept of "scale-dependent dispersion phenomena" or "non-Fickian" processes, then follow. Afterward, the class examines applications of the convection-dispersion equation to contaminant transport in streams and techniques for estimating dispersion coefficient.

Subsequently, the convection-dispersion model is extended to solute transport processes in aquifers and the vadose zone. Solute transport experiments in 1-D soil columns are examined first, with the introduction of the concept of dispersivity, including its relationship with the soil-column-scale heterogeneity. The validity of the convection-dispersion concept for column experiments under various conditions is then discussed. Alternative solute transport models (such as dead-end pore or moble-immoble domain models) are explored. The usefulness of Fick's law for solute transport processes in unsaturated media is investigated (Padilla et al., 1999). The class then proceeds to the classical design and interpretations of field tracer tests (including both forced-gradient and natural gradient tests). Using well-controlled and characterized field tracer experiments (Mas-Pla et al., 1995; Yeh et al., 1996), the class explores the inadequacy of the classical methods for interpreting tracer experiments.

The pros and cons of the stochastic analysis of macrodisperion for field-scale problems are discussed (Yeh, 1987 and 1992; Harter and Yeh, 1998). The class ends with the introductions of new ways to design and interpret field tracer tests, and to predict solute transport in both saturated aquifers and in the vadose zone (Harter and Yeh, 1996; Li and Yeh, 1999).

During the course, a multi-dimensional variably saturated model will be used to explore the effects of heterogeneity at various scales on the validity of the dispersion concept, which relies on Fick's law, to facilitate a better understanding of solute transport processes in porous media.