001-2-5067 Introduction to contaminant hydrology (3 credits)

Lecturer: Dr. Scott K. Hansen

The course covers physical and chemical processes governing the transport of solutes in groundwater, with an emphasis on mathematical and computer modeling techniques for prediction of contaminant migration. Hydrogeological, technical, physical and biological processes of contaminant transport and transformation are all covered, alongside state-of-the-art analytical and numerical solution techniques.

Course outline

1. Flow in the subsurface [6 hours]
- Groundwater and aquifers
- Continuum approach to porous medium and REV conception
- Hydraulic conductivity, Darcy's law, mass balance (continuity) equation
- Groundwater flow equation, initial and boundary conditions
- Transmissivity, 2D flow approximations

2. Contaminant transport in the subsurface [6 hours]
- Sources of groundwater contamination
- Molecular diffusion, advection and hydrodynamic dispersion
- Fick's law; mass balance equation
- Advection-dispersion equation; initial and boundary conditions

3. Determining flow and transport parameters [3 hours]
- Subsurface as information-poor environment
- Core samples, bench-scale testing, and empirical relations
- Pumping tests
- Single- and multi-well tracer tests

4. Coupling of chemical reactions and transport [6 hours]
- Adsorption and exchange processes
- Dissolution and precipitation processes
- Radioactive decay
- Biodegradation models; first-order, Monod kinetics
- Bimolecular reactions; the mass action law
- Advection-dispersion-reaction equation

5. Flow heterogeneity [3 hours]
- Scale problem of hydrodynamic dispersion
- Macrodispersion approach
- Subordination approach; transition time distribution
- Continuous-time random walk models of heterogeneous advection

6. Mobile-immobile mass transfer [3 hours]
- Kinetic sorption and diffusive sinks
- First-order mass-transfer models and the retardation factor approximation
- Multi-rate mass transfer and memory functions
- Continuous-time random walk models of MIMT

7. Methods of solution [6 hours]
- Analytic solution with integral transforms
- Numerical inversion of the Laplace transform
- Finite difference and finite volume numerical techniques
- Particle tracking

8. **Modelling flow and transport with MODFLOW and Aurora** [6 hours]
    - Developing a realistic model in ModelMuse
    - Adding boundary conditions and running the model
    - Particle tracking with Aurora
    - Visualization of results

Structure of final grade
Evaluation will be through a combination of problem sets and final examination, with a 100% final option.