Migration of Solutes and Contaminants in Groundwater
0-206-2-5081
Lecturer: Prof. Alex Yakirevich

The course considers physical and chemical processes governing the transport of solutes in groundwater. Hydrogeological, technical, physical and biological aspects are reviewed. State-of the art analytical and numerical solution models. The methodology of migration parameter estimation. Use of mathematical modeling for predicting contaminant migration and definition of protection zones. Case studies of trace tests and contaminant plume.

Course Content

1. Introduction into subsurface hydrology - 6 hours

* Groundwater and Aquifers

* Sources of groundwater contamination

* Subsurface as multiphase and multicomponent system

* Continuum approach to porous medium, REV conception

* Porosity, Density, Concentration

* Darcy's law, mass balance (continuity) equation.

* Transmissivity, Dupuit assumption,

* Flow equation, initial and boundary conditions

2. Mass transport in the subsurface - 6 hours

* Molecular diffusion, Fik's law

* Advection and hydrodynamic dispersion

* Scale problem of hydrodynamic dispersion

* General mass balance equation

* Initial and boundary conditions

3. Analytical methods of solution – 3 hours

* Review of important solution methods

* Solutions of a 1D advective-dispersion problem.
* Multidimensional Transport

4. Coupling of chemistry and transport in pollutant transport modeling - 6 hours

* Adsorption and exchange processes, the retardation factor
* Dissolution and precipitation processes
* Radioactive decay, biodegradation
* Thermodynamic equilibrium approach, Multicomponent transport

5. Density dependent flow and transport, sea water intrusion - 3hours

* Ghyben-Herzberg approach
* Sharp interface model
* Hydrodynamic model
* Examples of simulation

6. Introduction into numerical methods - 3 hours

* Finite difference method
* Finite element method

7. Techniques of parameters estimation - 6 hours

* Fundamental approach and algorithm
* Migration tests in laboratories
* Field tracer experiments
* Trial-and-error method
* Solution of inverse problem with objective functions

8. Groundwater protection and remediation - 5 hours

* Design of sampling network, sampling methods
* Methods for detecting contamination
* Corrective actions
* Injection/Withdrawal systems
* NAPL recovery, bioremediation
* Steps for dealing with problems of contamination

9. Modeling contaminant transport - 1 hour

* General principles of simulation of underground migration processes
* System approach and problem of model choice
* Making decision and mathematical modeling
* Main rules of modeling process.
* Case study in the application of a flow and transport model

Home assignments to be developed

Exercise with a code (Visual Modflow & MT3D) to simulate flow and transport problem in groundwater.

Structure of the final grade

Component	Weight
1. Home exercises	30%
2. Visual Modflow & MT3D class tests	20%
3. Theoretical test	20%
4. Final Home Exam (project with Visual Modflow)	30%

Bibliography

1.   Bear, J. Dynamic of Fluids in Porous Media, 1972.
2.   Bear, J. Hydraulics of Groundwater, 1979.
3.   Bear, J. and Verruijt, A. Modeling Groundwater Flow and Pollution, 1987
4.   Bresler, E., McNeal, B.L. and Carter D.L. Saline and Sodic Soils. Principles, Dynamics, Modeling, 1982.
5   Fetter, C.W., Contaminant Hydrogeology, 1993, 1999.
6.   Fried, J.J. Groundwater Pollution. 1975.
7.   Freeze, R.A. and Cherry, J.A., Groundwater, 1979.
8.   Domenico, P.A. and Schwartz, F.W. Physical and Chemical Hydrogeology, 1990.
9.   Marsily, C. de, Quantitative Hydrogeology, 1986.