קורס 2062526111 - זרימה והסעה בתווך לא רווי
Flow and Transport in the Unsaturated Zone

Lecturer: Prof. Alex Yakirevich

The course presents methods for modeling migration processes of water and solutes in the unsaturated zone of soil. Hydrogeological, technical, physical and biological aspects are reviewed. State-of the art analytical and numerical solution models, methods for estimating migration parameters, and the methodological aspects of using models for prediction are presented.

Course Content

1. Introduction into unsaturated zone hydrology - 3 hours

* Main objective of migration processes simulation
* The soil profile
* Soil as a multiphase and multi-component system
* Volume and mass relationship of soil constituents
* Soil texture, soil classes and soil structure
* Forms of water in soil, measuring soil water content

2. Modeling flow in the unsaturated zone - 9 hours

* Concept of wettability, Capillary pressure
* Soil potential, retention curve
* Pedotransfer functions, UNSODA database
* Darcy's law for the unsaturated zone, hydraulic conductivity
* Equation of continuity
* Richards equation
* Initial and boundary conditions
*Exercises with the UNSODA database and HYDRUS1D codes

3. Mass transport in the subsurface - 6 hours

* Molecular diffusion, advection and hydrodynamic dispersion in the unsaturated zone
* General diffusion-advection equation. Initial and boundary conditions
* Coupling of chemistry and transport in pollutant transport modeling
* Exercises with the HYDRUS1D and HYDRUS2D codes

4. Soil-Plant-Atmosphere relations, Heat transfer - 6 hours

* Evaporation, transpiration, root uptake
* Energy budget
* Heat conduction and advection
* Phase exchange, storage and transformation processes
* Heat balance equation, Initial and boundary conditions
* Coupling phenomena: osmosis, thermodiffusion

5. Introduction into numerical methods - 2 hours

*Numerical methods versus analytical solutions
* Finite difference method
* Finite element method

6. Techniques of parameters estimation - 6 hours

* Tests in laboratories for unsaturated flow and transport
* Field experiments
* Trial-and-error method
* Solution of inverse problem with the objective functions
*Exercises with the HYDRUS1D code

7. Forecast of water flow and solute transport in variably saturated soil - 6 hours

* Complete statement of a model
* Data requirement
* Methods of forecast

Course includes 2 hours of lecture and 1 hour of theoretical exercises per week

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The final grade will be based on

1) Exercises to estimate water flow and solute transport parameters, solving inverse problem, and using computer codes to solve a problem of flow and transport in the unsaturated zone - 50%
2) Final theoretical examination – 50%

Recommended Reading:

1. Bear, J. Hydraulics of Groundwater, 1979.
2. Bear, J. and Verruijt, A. Modeling Groundwater Flow and Pollution, 1987
3. Beaver, L.D., Gardner, W.H. and Gardner, W.R. 1972. Soil Physics
4. Bresler, E., McNeal, B.L. and Carter D.L. Saline and Sodic Soils. Principles, Dynamics, Modeling, 1982.
5. Hanks, R.J., and Ashcroft, G.L., Applied Soil Physics, 1980
6. Hillel, D. Soil and Water: Physical Principles and Processes, 1971
7. Hillel, D. Fundamentals of Soil Physics, 1980
8. Hillel, D. Introduction to Soil Physics, 1982
9. Jury, W.A., Gardner, W.R., Gardner, W.H. Soil physics, Wiley & Sons, 1991
10. Koorevaar, P. Menelik, G., Drisken, C. Elements of Soil Physics, 1983
11. Marsily, G.de. 1986. Quantitative Hydrogeology. Groundwater Hydrology for Engineers. Academic Press, Orlando.
12. Miyazaki, T. Water Flow in Soils, 1993.