MODELING SOIL WATER FLOW AND CHEMICAL TRANSPORT

1	Course Title:	MODELING SOIL WATER FLOW AND CHEMICAL TRANSPORT
2	Course Code:	TOP5972
3	Type of Course:	Optional
4	Level of Course:	Second Cycle
5	Year of Study:	1
6	Semester:	2
7	ECTS Credits Allocated:	6.00
8	Theoretical (hour/week):	2.00
9	Practice (hour/week):	2.00
10	Laboratory (hour/week):	0
11	Prerequisites:	None
12	Language:	Turkish
13	Mode of Delivery:	Face to face
14	Course Coordinator:	Dr. Ögr. Üyesi Rifat AKIŞ
15	Course Lecturers:	Yok
16	Contact information of the Course Coordinator:	rifatakis@uludag.edu.tr, 0224.2941531, U.Ü. Ziraat Fak. Toprak Bilimi ve Bitki Besleme Bölümü. Görükle-Nilüfer/Bursa
17	Website:	
18	Objective of the Course:	This course provides the student with essential skills and knowledge of the applications of basic principles governing solute and water transport in soil porous media and student concentrates on soil vadose zone hydrologic processes. Soil spatial variability and heterogeneity will be considered in the modeling processes. Using and comparing models, students will obtain the capability to transfer a physical problem to a mathematical model.
19	Contribution of the Course to Professional Development:	the content and practical applications of this course aims to contribute to efficient use of the fundamentals of soil physics by the students and researchers in the area of water resources and soil and plant sciences. This course closely connects the soil science students and researchers with their counterparts in the area of environmental science, civil engineering, hydrology, agricultural sciences, and geophysical sciences. This course closely connects and increases the relationships of aforementioned science and soil physics.
20	Learning Outcomes:	
	1	Upon completing the course, the students should be able to discuss and describe advection, dispersion, and diffusion processes in soil
	2	Evaluate the chemicals affecting these processes
	3	Develop HYDRUS/CHAIN2D codes that represent flow and chemical transport conditions in soil profile
	4	Analyze the output for visual post-processing and a better interpretation of flow and/or chemical plume
	5	Write a small computer code to approach the solution to saturated and unsaturated flow equations,
	6	Develop a breakthrough curve for the chemicals' behaviors in the soil profile
	7	Understand components such as sink/source terms and theory of the flow and transport processes in soil

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21	Course Content:

Course Content:

Week	Theoretical	Practice
1	Soil water balance in the vadose zone of the field: precipitation, surface runoff, evapotranspration A first approximation to real evapotranspration and groundwater recharge, a simplified approach to drainage and capillary rise Soil water storage term, simulation of soil water storage (excel solver, a spreadsheet model simulation), a multilayer soil water balance simulation	Course is going to be interactively using Computers and text material and components of the software for the construction of the model -Simulations in excel spreadsheet via solver
2	Water retention in soils: Soil water retention curve, differential water capacity, air entry value, residual water content, Pore size distribution, effect of temperature on pressure head, hysteresis	Using field data and laboratory data of soil water retention, 1D transport in a uniform flow field will be evaluated.
3	Equations governing the flow process, Darcy's equation, Advection-dispersion equation (ADE) Steady-state flow of water in saturated soil, permeability, Estimation of saturated hydraulic conductivity Numerical models of water flow Statistical data processing,	processes
4	Variably saturated water flow: governing flow equations, root water uptake, unsaturated soil hydraulic properties, initial and boundary conditions	2D transport in a uniform flow field: evaluation of advection, dispersion, diffusion, and chemical reaction
5	Flow through unsaturated soil: Fundamentals of steady-state flow and transient flow, solutions to flow equations Models of unsaturated hydraulic conductivity: Gardner's equation, Burdine and Brooks Corey equations, Mualem and van Genuchten theory,	2D transport in a uniform flow field: evaluation of advection, dispersion, diffusion, and chemical reaction processes

Activites	Number	Duration (hour)	Total Work Load (hour)
Theoretical	14	2.00	28.00
Practicals/Labs	14	2.00	28.00
Self study and preperation	12	3.00	36.00
Homeworks	6	5.00	30.00
Projects	1	30.00	30.00
Field Studies	0	0.00	0.00
Midterm exams	1	10.00	10.00
Others	0	0.00	0.00
Final Exams	1	18.00	18.00
Total Work Load			180.00
Total work load/ 30 hr			6,00
ECTS Credit of the Course			6.00

6	Steady-state evaporation or seepage, Steady-state infiltration field methods-the disc infiltrometer, Prediction of unsaturated hydraulic conductivity based on soil water retention	2D transport in a uniform flow field: evaluation of steady-state flow with initial and boundary conditions in HYDRUS2D
7	Elementary soil hydrological processes: Steady-state vertical flow: capillary rise and constant flux infiltration, Vertical infiltration under pressure head boundary conditions: Philip's equation, Haverkamp's equation, The Green-Ampt equation Vertical infiltration under flux boundary condition: finger flow and preferential flow, redistribution, Infiltration-based methods to estimate soil hydraulic properties, two-dimensional flux boundary conditions, infiltration from line and point sources, internal drainage Internal drainage of groundwater-affected soils, unit gradient drainage, drying bare soil by evaporation	Numerical models and their solutions for veritcal infiltration will be tested in HYDRUS2D
8	Solute transport in soil: Basic processes: convection, diffusion, dispersion, hydrodynamic dispersion Total solute flux, Chemical reactions and classes, Fast reactions (classes I through III), Slow reactions (classes IV through VI) Convection-dispersion equation (CDE), components of solute transport equation, general problem definition, simplified CDE solutions, Breakthrough curves and solutions to the CDEs, stream tube models inital and boundary conditions for the construction of a flow equation Stochastic descriptions of solute transport.	2D transport in a uniform flow field: evaluation of advection, dispersion, diffusion, and chemical reaction processes
9	Numerical solution of water flow governing equations: space and time discretizations; numerical solution strategies: iteration process, discretization of water storage term, time step control, treatment of pressure head boundary conditions	Mathematical formulations using componets of the software for the construction of the model
10	Flux and gradient boundary conditions, atmospheric boundary conditions and seepage faces, treatment of tile drains, water balance evaluation, nodal flux computations, water uptake by plant roots, evaluation of soil hydraulic properties, steady-state analysis of water flow	Mathematical formulations using componets of the software for the construction of the model

11	Numerical solution of solute transport governing equations: space and time discretizations, numerical solution algorithms, solution process	Mathematical formulations using componets of the software for the construction of the model
12	Upstream wighted formulation, implementation of first type boundary conditions, implementation of third type boundary conditions, mass balance calculations	Mathematical formulations using componets of the software for the construction of the model
13	Problem definition: construction of finite element mesh, coding of soil types and subregions, coding of boundary conditions, program memory requirements, matrix equation of solvers	Working with componets of the software for the construction of the model
14	Input data: description of data input blocks, example input files; output data: description of data output files, example output files Overview of modeling steps	Working with componets of the software for the construction of the model

22	Textbooks, References and/or Other Materials:	Hillel, D. 2002. Environmental Soil Physics. J. Simunek and M. Th. Van Genuchten. 1994. CHAIN_2D Code for simulating Two-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably saturated Porous Media. Research Report No.136, U.S. Salinity Laboratory, Agricultural Research Services U.S. Department of Agriculture Riverside, California J. Simunek and R. Van Genuchten. HYDRUS2D/3D. https://www.pc-progress.com/en/Default.aspx?h2d-tutorials Klaus Bohne. 2005. An Introduction into Applied Soil Hydrology.

23 Assesment

TERM LEARNING ACTIVITIES	**NUMBER**	**WEIGHT**
Midterm Exam	1	20.00
Quiz	0	0.00
Home work-project	7	50.00
Final Exam	1	30.00
Total	9	100.00
Contribution of Term (Year) Learning Activities to Success Grade		70.00
Contribution of Final Exam to Success Grade		30.00
Total		100.00
Measurement and Evaluation Techniques Used in the Course		Homework assignment, quiz, term papere, web page preparation

24 ECTS / WORK LOAD TABLE

25 CONTRIBUTION OF LEARNING OUTCOMES TO PROGRAMME QUALIFICATIONS

	PQ1	**PQ2**	**PQ3**	**PQ4**	**PQ5**	**PQ6**	**PQ7**	**PQ8**	**PQ9**	**PQ10**	**PQ11**	**PQ12**	**PQ13**	**PQ14**	**PQ15**	**PQ16**
ÖK1	2	3	3	3	4	3	3	3	4	4	5	5	5	0	0	0

ÖK2	2	3	3	3	4	4	3	3	4	2	3	3	3	0	0	0
ÖK3	2	3	3	3	4	3	2	3	3	3	4	4	4	0	0	0
ÖK4	2	3	3	4	3	3	4	3	4	3	3	3	5	0	0	0
ÖK5	3	3	3	4	4	4	3	3	4	4	4	4	4	0	0	0
ÖK6	2	2	2	2	3	3	3	3	5	3	4	3	5	0	0	0
ÖK7	4	4	5	5	4	4	5	5	4	5	4	4	4	0	0	0

LO: Learning Objectives PQ: Program Qualifications

Contribution Level:	**1 very low**	**2 low**	**3 Medium**	**4 High**	**5 Very High**