Groundwater

MODULE TITLE	Groundwater
LECTURER(S)	Dr Drobot and Dr Ivetic
ECTS VALUE	8
PREREQUISITES	Hydrology
COREQUISITES	None
DURATION OF MODULE	15 weeks

TOTAL STUDENT STUDY TIME

Overall, the module is expected to involve students in approximately 200 hours of learning: 12 5-hour lectures; 58 hours assignments; 78 hours private study; 4-hour examination.

WEB LINK http://www.water-msc.org/en/wrem302.htm

AIMS

This module aims to provide a basic knowledge of groundwater systems (saturated and unsaturated media) and basic equations for flow and transport, as well as basic principles for groundwater management problems. It also offers gaining practical experience in using groundwater modelling.

INTENDED LEARNING OUTCOMES

1. Subject Specific Knowledge, Understanding and Skills

By the end of this module, the students should:

a) have acquired understanding of groundwater systems, their characteristics and functioning;
b) have acquired basic knowledge of groundwater management problems;
c) be able to make appropriate and critical use of groundwater modelling and management principles.

2. Core Academic Skills

By the end of this module, the students should:

a) be able to identify, formulate and analyse a groundwater management problem;
b) be able to critically assess research results;
c) have acquired some practical experience of using groundwater modelling tools.

3. Personal and Key Skills

By the end of this module, the students should have:

a) improved further the necessary skills for independent learning;
b) enhanced report and presentation skills;
c) improved some IT skills.

LEARNING/TEACHING METHODS

Lectures, problem sheets, tutorials.

ASSIGNMENTS

Two assessed coursework assignments (3,000 equivalent words each including graphs and tables).

Problem sheets and computer based problem solving.

ASSESSMENT

Examination paper (60%), Course work (40%)
3-hour examination - use of notes and book allowed
2 assignments on practical application of modelling tools (2x20%, 6,000 equivalent words, including graphs and tables).

SYLLABUS PLAN

1. **Module overview.**
2. **Porous media.**
   The solid phase. Genesis and structure of the solid phase. Particle size analysis. Representative Elementary Volume. Porosity. Soil density.
   The liquid and the gaseous phase. Water properties. Origin of the sub-surface water. Subsurface water distribution. Forms of water in porous media. Phase relationships.
3. **Aquifers, aquitards and aquicludes.** Geological characterization of the aquifer formations. Hydrogeological characterization of the aquifer formations. Unconfined and confined aquifers. Natural recharge and discharge of the aquifers. Water table and piezometric surface. Water balance. Water reserve and water resource.
4. **Groundwater flow and groundwater parameters.** Microscopic and macroscopic concepts of groundwater flow. Darcy's experiment and Darcy's law. Limits of validity. Hydraulic conductivity in saturated media. Heterogeneity and anisotropy. Darcy's law in 3D. Darcy's law in unsaturated media. Hydraulic conductivity in unsaturated media.
5. **Flow equations in porous media.** Continuity equation. General equation of water movement in unsaturated media. General equation of water movement in saturated media. Two-dimensional saturated flow equation.
6. **Transport equation in porous media.** Transport mechanism of miscible pollutants. Main processes in aquifer: convection, diffusion, dispersion, desorption, rock dissolution, physical and chemical sorption, sedimentation, biodegradation, decay, etc. Partitioning processes. Freundlich and Langmuir isotherms. Retardation and decaying processes. Transport equation for miscible pollutants.
7. **Field and laboratory tests.** Groundwater flow parameters. Transport parameters.
8. **Mathematical modelling of flow and transport.** Data collection and GIS database. Developing the conceptual model. Selecting the computer code. Setting-up the specific site model. Calibrating the model. Validating the model. Conducting model predictions. Auditing the model.
9. **Interactive Ground Water (IGW).** General description of the program. Using IGW for flow and transport modelling.
10. **Case studies.** Deep structure influence on water table. Water resources evaluation. Aquifer pollution due to industrial activities. Delineation of wells protection area. Optimal use of surface and ground water. Case studies of artificial recharged water resources. Storage facilities and purification potentials of aquifers.
11. **Remediation of polluted aquifers.** Levels of groundwater remediation. Difficulties in groundwater remediation. Techniques and methods for groundwater remediation. Natural attenuation.
12. **Wellhead protection zones.** Technical regulation. Land Use planning. Application of mathematical modelling in protection zones delineation.

INDICATIVE BASIC READING LIST

1. Fetter C. W., *Applied Hydrogeology*, 2001, 4th Edition. Prentice Hall, New Jersey.
2. Fetter C. W., *Contaminant Hydrogeology*, 2001, 2nd Edition. Prentice Hall, New Jersey.
3. Freeze, R.A. and Cherry, J.A., 1979. *Groundwater*. Prentice Hall, New Jersey.

EXTENDED READING LIST

Spitz, K. and Moreno, J., 1996. *A Practical Guide to Groundwater and Solute Transport Modelling*. John Willey and Sons, New York.

AUTHORS

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