Nastavni plan za združeni studij **grupa**: Water Management

ZDRUŽENE ŠKOLE – JOINT SCHOOLS

Geo-Engineering and Water Management - Courses and lecturer's			Remarks
MWG 1	HYDROGEOLOGY	B. Biondić, J. Fank, R. Jecl, K. Posavec, S. Semprich, L. Trauner	obvezni
MW 1	WATER MANAGEMENT	E.Ocvirk, B. Biondić, I. Ijjas, H. Zojer	obvezni
MW 2	MODELLING IN WATER MANAGEMENT	J. Fank /H.Kupfersberger, G. Gjetvaj, D.Bekić, J. Józsa, Z. Nakić, J. Szilágyi, J.Kramer	obvezni
OW 1	HYDROGEOCHEMISTRY	M. Dietzel, S. Kapelj, B.Trček	izborni
OW 2	VULNERABILITY, HAZARD AND RISK ASSESSMENT	B. Biondić, H. Zojer , B. Trček	izborni
OW 3	WATER TREATMENT AND ARTIFICIAL RECHARGE	H. Kainz, H. Zojer	izborni
OW 4	WATER SUPPLY AND DISTRIBUTION	R. Jecl, H. Kainz	izborni
OW 5	MONITORING SYSTEMS AND GIS	R. Biondić, H.Zojer	izborni

Joint Doctoral Programme "Geo-Engineering and Water Management"	
POSTGRADUATE STUDY:	Joint Doctoral Programme Geo-Engineering and Water Management
COURSE TITLE:	**HYDROGEOLOGY**
COURSE STATUS:	Mandatory course (MWG 1)
LECTURER'S	**Božidar Biondić, Johann Fank, Renata Jecl, Kristijan Posavec, Stephan Semprich, Ludvik Trauner**

COURSE DESCRIPTION:

Karst

- Basic geological characteristics of Karst areas; Basic characteristics of Karst aquifers; Application of different research methods; Aquifers human impact; Experiences of different European countries in the protection of Karst aquifers; Vulnerability mapping; Criterions for the definition of protection zones; Management of coastal Karst aquifers – fresh-salt water interaction – remediation methods; Groundwater intake structures in Karst areas; Case studies in different Mediterranean countries; Water protection in national parks and other protected areas.

Granular soils

- The origin of porosity and permeability; Groundwater movement; Main equations of flow and solute transport; Sources of groundwater contamination; Contaminants in groundwater; Risk assessment; Solute plumes as a manifestation of processes; Design and quality assurance issues in solute sampling: Sampling methods; Indirect methods for detecting contamination; Methods of remediation: Containment; Pump and treat; Interceptor systems; Soil-vapour extraction; Air sparging; Intrinsic Bioremediation; Bioventing and bioslurping; Abiotic chemical destruction. Case studies in Remediation.

Unsaturated soils

- Soils (nature and origin, soil profile, texture and structure, classification, clay minerals); Oxides and hydroxides (nature and origin, size, cation exchange, specific adsorption); Natural organic matter (nature and origin, geochemical reactions, interactions between organic matter and anthropogenic chemicals); Reactions in the unsaturated zone (gas dissolution and redistribution, carbonate and silicate dissolution, sulphide oxidation, gypsum precipitation and dissolution, ion exchange and sorption, organic reactions); Anthropogenic influences (agricultural pollution, industrial pollution, solid and liquid waste, petroleum contamination, acid rain, mining); Pollutants (heavy metals - origin and interactions; pesticides, organics); Chemical analysis of water, soils and sediments (total versus partial; analytical methods); Mineralogical analyses of soils and sediments; Remediation of contaminated soils.

Soil sedimentation

- Problems of soil sedimentation; Geomechanical, chemical and microbiological laboratory tests; Hydrodynamical analysis of sediments; Monitoring techniques.

Seepage flow in jointed rock

- Modelling of seepage flow through fissured rock; Laboratory and field tests according to groundwater flow in rock; Equation for steady flow of incompressible viscous liquids; Laminar and turbulent flow in fissures; Discrete and continuous models; Seepage forces and hydrostatic uplift; Input data for the design of structures.

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES (*max. 500 characters – describe main goal of the subject in terms of knowledge and skills that a student would acquire by taking the course*):

The lecture will be based - beside others - on the EU COST action 65 ''Hydrogeological aspects of groundwater protection in Karst areas'', COST action 620 ''Vulnerability" and COST action 621 ''Management of coastal Karst aquifers''. Students will acquire knowledge on contaminants in groundwater and methods of remediation, acquire skills in applying knowledge on solving specific problem; Recognize soil horizons and types, describing soil characteristics; Identify anthropogenic influences on soil, sediments and water; Describe main reactions in the unsaturated zone; Interpret mineralogical and chemical results for soils and sediments; Development opinions, judgements and decisions for soil remediation; Acquainted with the principles of sedimentation of soil in water and seepage flow in rock.

RECOMMENDED LITERATURE (*with detailed data on publisher and year of publication*):

1. Appelo, C.A.J.; Postma, D. (1994). Geochemistry, Groundwater and Pollution, A.A.Balkema Publishers, 400.
2. Aquifer Remediation Wells, The Class V Underground Injection Control Study (1999). EPA, Office of Groundwater and Drinking Water (4601), EPA/816-R-99-0124p, (available on web site).
3. Biondić, B.; Biondić, R.: Dukarić, F. (1988). Protection of Karst aquifers in the Dinarides in Croatia. Environmental Geology, Springer, vol. 34/4, pp 309-320.
4. Biondić, B.; Kapelj, S.; Mesić, S. (1997). Natural tracers – indicators of the Vrana lake water origin – Cres, Croatia. Intern. Symp. On water tracing, Balkema, Portorož, Slovenia.
5. Biondić, B.; Biondić, R. (2003). State of sea water intrusion of the Croatian coast. Book ''Coastal aquifers intrusion technology: Mediterranean countries /Lopez-Geta, de Dios Gomez, dela Orden, IGME, Spain, pp 225-238.
6. Bradl, H.B. (ed.) (2005). Heavy Metals in the Environment: Origin, Interaction and Remediation.- Interface Science and Technology – Volume 6, 269.
7. Dixon, J.B.; Weed, S.B. (1989). Minerals in Soil Environments.- Soil Science of America, 1244.
8. Domenico, P.A.; Schwartz F.W. (1998). Physical and Chemical Hydrogeology.
9. Hsai-Yang Fang: Introduction to Environmental Geotechnology.- CRC press. Boca Raton, New York, 652.
10. Malcolm E.S. (ed.) (2001). Handbook of Soil Science.- CRC press. London-New York-Washington.
11. Richardson, M. (ed.) (1995). Environmental Toxicology Assessment.- Taylor & Francis, 438.
12. Saether, O.M.; de Caritat, P. (1997). Geochemical Processes, Weathering and Groundwater Recharge in Catchments.- A.A.Balkema Publishers, 400.
13. Schüring, J.; Schulz, H.D.; Fischer, W.R.; Böttcher, J.; Duijnisveld (eds.) (2001). Redox - Fundamentals, Processes and Applications.- Springer, 251.
14. Survactant-Enhanced Aquifer Remediation (SEAR) Design Manual, NFESC Technical Report TR-2206-ENV, Naval Facilities Engineering Command, Washington DC, (available on web site).
15. Survactant-Enhanced Aquifer Remediation (SEAR) Implementation Manual, NFESC Technical Report TR-2206-ENV, Naval Facilities Engineering Command, Washington DC, (available on web site).
16. Morrison, G.L.; Fan, J. (1998). Reservoir sedimentation handbook. USA.
17. Thornton, I (ed.) (1983). Applied Environmental Geochemistry.- Academic Press, 501.
18. Tulipano, G.; Biondić, B. et al. (2005). Groundwater management of costal karst aquifers. EU COST 621 action, Luxemburg.
19. Wittke, W. (1990). Rock Mechanics – Theory and Applications with Case Histories, Springer Verlag, Berlin.
20. Zwahlen, F. et al. (2004). Vulnerability and risk mapping for the protection of carbonate (karst) aquifers. EU COST action 620, Bruxelles.

QUALITY ASSURANCE METHODS:

An anonymous questionnaire will be filled in by all of the course participants. This procedure is compulsory for all subjects and is aimed at evaluation both of the teacher's performance (quality of delivery) and of the overall content and structure of the course.

15.02.2011, Sem

Joint Doctoral Programme “Geo-Engineering and Water Management”	
POSTGRADUATE STUDY:	Joint Doctoral Programme Geo-Engineering and Water Management
COURSE TITLE:	**WATER MANAGEMENT**
COURSE STATUS:	Mandatory course (MW 1)
LECTURER'S	**Eva Ocvirk, Božidar Biondić, István Ijjas, Hans Zojer**

COURSE DESCRIPTION:

- Water resources management concept
- Recognition of water resources management problems
- Men and water in history
- Water demand and other problems in connection with water
- Water in nature, quantity, quality, and water balance
- Water resources management feasibility
- Water resources principles
- Multidisciplinary approach and interdisciplinary work (teamwork) in WRM (water resources management)
- WRM goals. Water law
- Optimization standpoints and their measures
- Economical, social, ecological and technical standpoints
- Investigations area and methods. One-dimensional criteria and multicriteria optimization
- Present status of WRM in Croatia and in the world
- Water use, water protection and protection from water
- Multipurpose projects. Reservoirs
- Multipurpose projects environmental impacts and acceptable changes
- WRM as a part of a sustainable development. WRM achievement. WRM improvement possibilities
- Conceptual framework: management approaches, implementation plans
- Management matrix for regional aquifers
- Long-term groundwater level measurements reflecting optimal groundwater use
- Use of water depending on qualitative demands of end-users: drinking water, water for industrial purposes, water for beverage industries, water for irrigation, use of treated waste water
- Interchange of surface and groundwater
- Importance of groundwater in different regions: climatic and hydrogeological boundary conditions
- Socio-economic aspects in water management
- Aspects on capacity building in water management
- Groundwater resources management for aquifers with different yield
- Conflicts in water utilisation planning
- Hazards and protection of groundwater
- Important issues at EU-level: Water Framework Directive, trans-boundary water resources management, sustainable coastal aquifer management
- Theoretical assumption of management system
- OUN and EU declarations about water resources
- EU Water Directives (purpose of join approach, definition of concept, coordination of administrative structure in water area, aims of water resources protection, water bodies characteristics, protected areas, potable water, quality control of surface and ground waters)
- Role of GIS in water management system
- Case studies
- River basin management plans
- Public relation
- UNDP Directions for water resources management
- Challenging issues in the Danube River Basin District Management Plan
- Water scarcity management and floodrisk management in the context of EU Water Framework Directive
- Incorporating climate change in the River Basin Management Plan
- Assessment of world water resources
- Dams and development - a new framework for decision making
- Economic importance of water

- Demand management
- Water footprint, virtual water flows and water trade

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES (*max. 500 characters – describe main goal of the subject in terms of knowledge and skills that a student would acquire by taking the course*):

Acquire knowledge on integral, comprehensive, complex and multidisciplinary approach to water resources management problem solving. Understanding of requirements for different kinds of water utilisation. Advise for decision makers in different fields of application. Principles of water protection issues, surface water and groundwater. Effects of free waste water on the environment. Students will be able to incorporate draugt management, flood risk management, climatic change and demand management aspects in river basin management plans. They will have the skills to apply the concepts and methodologies of the economic analyses of water use and virtual water flows between the different countries and regions of the world.

RECOMMENDED LITERATURE (*with detailed data on publisher and year of publication*):

1. Biswas, A.K. (1997). Water resources: Environmental planning Management and Development. McGraw–Hill, New York.
2. Buras, N. (1972). Scientific Allocation of Water Resources. American Elsevier Publishing Comp., New York.
3. Burchi, S. (1994). Preparing National Regulations for Water Resources Management (Principles and Practice), FAO Legislative Study, HMSO.
4. Dukstein, L.,; Plate, E..J. (1987). Engineering Reliability and Risk in Water Resources. Dodrecht, Martinus, Nijhoff.
5. Grigg, N.S. (1996). Water Resources Menagement Principles, Cases and Regulations. New York, McGraw-Hill.
6. Hall, W.A.; Dracup, J.A. (1970). Water Resources System Engineering. McGraw-Hill, New York.
7. Ijjas, I. (2004). Implementation of the WFD in the Danube Basin. GI for IRBM, EC High-level Scientific Conferences, June 2004.
8. ICPDR (2008). Draft Danube River Basin District Management Plan, Part A – Basin-wide overview, Version 3. www.icpdr.org.
9. Ijjas, I.; Szlávik, L. (2000): Institutional framework for water management in Hungary, Eurowater-CEC vertical report. In: Water Resources Management in the Czech Republic, Hungary, Lithuania, Slovenia, DVWK Bulletin 21, DVWK, 191-380.
10. Jain, S.K.; Singh, V.P. (2003). Water resources systems, planning and management. Elsevier, Amsterdam.
11. Karamouz, M.; Szidarovski, F.; Zahrae, B. (2003). Water resources system analyses. Lewis publisher US.
12. Linsley, R..K.; Franzini, J.B.; Freyberg, D.L. (1992). Water Resources Engineering. 4/re, McGraw-Hill.
13. Loucks, D. P.; van Beek, E. (2005). Water Resources Systems Planning and Management, An Introduction to Methods, Models and Applications - Studies and Reports in Hydrology. UNESCO Publishing.
14. Maniak, U. (1993). Hydrologie und Wasserwirtschaft. 3. Aufl., Springer, Berlin.
15. Margeta, J.; Azzopardi, E.; Iacovides, J. (1999). Directives for integral approach to the development, management and usage of water resources. UNEP, Centre for Regional Activities, Split.
16. UNESCO (2003). The United Nations World Water Development Report 1 – Water for People and Water for Life, UNESCO & Bergham Books.
17. UNESCO (2006). The United Nations World Water Development Report 2 –Water a Shared Responsibility, UNESCO & Bergham Books
18. Van de Giesen, N.; Yua, X.; Rosbjerg, D.; Fukushima, Y. (2007). Changes in water resources systems: Methodologies to maintain water security and ensure integrated management. IAHS Redbook Nr. 315.
19. WFD CIS (2008). Progress report on incorporating climate change in first River Basin Management Plans.
20. WMO-UNEP IPCC (2008). Climate Change and Water, IPCC Technical Paper VI, http://www.ipcc.ch/meetings/session28/doc13.pdf
21. Wilhite, D.A. (2001): Drought, a global assessment. Vol. I, II, Routledge, London, New York..
22. Zekster, I. S. (2000). Groundwater and environment. Lewis publisher US.

QUALITY ASSURANCE METHODS:

An anonymous questionnaire will be filled in by all of the course participants. This procedure is compulsory for all subjects and is aimed at evaluation both of the teacher's performance (quality of delivery) and of the overall content and structure of the course.

15.02.2011, Sem

Joint Doctoral Programme "Geo-Engineering and Water Management"	
POSTGRADUATE STUDY:	Joint Doctoral Programme Geo-Engineering and Water Management
COURSE TITLE:	**MODELLING IN WATER MANAGEMENT**
COURSE STATUS:	Mandatory course (MW 2)
LECTURER'S	**Johann Fank/H.Kupfersberger, Goran Gjetvaj, Damir Bekić, Zoran Nakić, Janja Kramer, János Józsa, József Szilágyi**

COURSE DESCRIPTION:

Convection, dispersion, diffusion, basic transport equation, Fickian diffusion, turbulent diffusion
flow and transport processes in the subsurface, fundamental principles of conceptual modelling, system properties, DNAPL, LNAPL, phase, relative permeability, subsurface modelling, flow and transport processes in fractured systems, parameter identification and up scaling, mathematical modelling, remediation techniques,
Mixing in inland and coastal waters, mixing phenomena, mixing in rivers, mixing in reservoirs, mixing in estuaries, jets and plumes, buoyant jet problems, design of ocean wastewater discharge system, Numerical modelling of wastewater plume advection, dispersion and decay

The application of Darcy law related to the aquifer contamination problems. Effect of the anisotropy on the contaminant transport in aquifer systems. Examples of the contaminant transport in isotropic and anisotropic aquifer systems. Distribution of contaminants (gaseous, dissolved and residual phases) and plume movement in unsaturated and saturated zone. The significance of high-resolution plume characterization and monitoring. Errors and misconceptions related to the use of traditional methods based on 2D contaminant distribution maps. Examples from the case studies. Principal transport processes and attenuation mechanisms in contaminant migration: advection, longitudinal and transverse dispersion, dispersivity, random effect of a molecular diffusion, first order decay, sorption isotherms. Examples of distribution coefficients for organic pollutants and heavy metals. Large-scale field tests and laboratory experiments for estimation of the retardation factor. Practical application of the retardation factor in groundwater contamination problems. A framework for application of groundwater contaminant transport models. Goals of contaminant transport modeling. Data collection and conceptual models. Selection of a computer code. Understanding of the groundwater flow system and domains of simulation for contaminant transport modeling. Spatial and temporal discretization in models. Initial conditions and methods for defining the initial concentration distribution in simulation. Comparison between flow and transport boundary conditions. Model input parameters: flow parameters, transport parameters, chemical parameters. Calibration, verification and validation of the model. Sensitivity analysis. Types and sources of uncertainty.

In order to address urgent problems in contaminant migration and to understand many natural geologic processes, we need to be able to model the movement of substances undergoing chemical reactions in ground-water systems. Predictive models will be used to assess the risks of chemical-waste disposal, to analyze contaminant migration from pollution sources, and to determine the susceptibility of aquifers to contamination. Models also are needed to investigate many rock-water interactions and the evolution of ground-water chemistry.
Transport and turnover processes are complex and difficult to observe and quantify in field. On the one hand, processes can not clearly be separated by chemical data and on the other hand, spatial and temporal characteristics of transport phenomena are difficult to resolve with the available experimental methods. Models are a useful help for the estimation of diffuse pollution of groundwater resources. They are essential for the spatial and temporal inter- and extrapolation of point measurements and snap-shots as for the assessment of scenarios e.g. of management alternatives.
Considerable progress has been made in the field of soil nitrogen modelling and reactive groundwater transport modelling. Coupling of soil and groundwater modelling is a straightforward approach to investigate the interactions between various processes. The need for a profound discussion on coupling processes and modelling stems from the major problems related to contamination of soil and subsoil in the EC countries and elsewhere. Technologies for remediation and restoration require deep knowledge and understanding of the involved processes with an adequate modelling approach in order to reach the plausible results which are applicable in practice.

Modelling methods for inland surface waters (rivers with floodplains, lakes and reservoirs).
Overview on the problem oriented numerical modelling methods in surface waters. Modelling of flow, mixing, sediment transport and bed morphology processes. Multidimensional approach. Grid-based models and Lagrangian particle tracking techniques.

Model implementation in complex conditions such as main channel with forested floodplains, or lakes with vegetated littoral zones. Planning and performing data acquisition for model calibration and verification, simplifications, information loss. Introduction to numerical solvers with capability of static adaptation to input data fields or dynamic adaptation e.g. to the modelled flow (including both space and time refinement or coarsening). Selected river and lake case studies, application of 2- and 3D methods in surface water hydro- and sediment dynamics projects.

Rainfall-runoff, channel flow and lake water balance modelling in system theory approach. Linear systems, including rainfall-runoff input-output models, various methods for determining the unit hydrograph, linear kinematic wave equation, various continuous and discrete cascade models, base-flow analysis, stochastic models and the Kalman-filtering. Non linear systems, including the implementation of non-linear processes in rainfall-runoff and channel flow models, effective rainfall and antecedent rainfall/infiltration. Geomorphic-based watershed models with non-linear storage, as well as GIS and remote control. Case studies in hydrological modelling.

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES (*max. 500 characters – describe main goal of the subject in terms of knowledge and skills that a student would acquire by taking the course*):

Students will learn some elements of multiphase flow and transport processes in the aquifers, inland and coastal waters. They will be able to make prognosis of coupled flow and transport processes in hydrosystems by experimental and numerical methods.

General: improving oral presentations, team work in problem solving, application of information technology.
Specific:
Understanding the processes that influence transport of contaminants in different aquifer systems.
Understanding of framework and basic concepts for application of transport modeling;
Solving three basic problem categories: 1. Testing of hypotheses (one or many) and quantification of the dominant processes influencing contaminant transport in groundwater; 2. Observation of concentration changes in time and risk assessment; 3. Prediction of contaminant distribution in groundwater with the aim to control pollution sources and to create alternative measures for groundwater restoration;
Analyzing the processes and mechanisms which influence contaminant behaviour in time and space;
Concluding on the causes and the consequences of the alteration of the groundwater quality due to anthropogenic influences;

Management of ground-water resources requires that the extent and rate of movement of contaminants in the saturated zones be understood. The contaminants have been and will continue to be both accidentally and deliberately introduced into ground- water systems. Some of these contaminants constitute very hazardous conditions. Because of the immediacy of such contamination problems, understanding of the physical and chemical processes needs to be increased rapidly. A main focus will be set on the distribution of pollutants in shallow aquifer systems from diffuse sources at a regional scale.

Students will have a good understanding of the fundamentals of a range of physical processes, advanced modelling techniques and information technology for inland surface water management.

Students will have a good understanding of the fundamentals of a range of physical processes, advanced modelling techniques and information technology for hydrological modelling.

RECOMMENDED LITERATURE (*with detailed data on publisher and year of publication*):

1. Appelo, C.A.J.; Postma, D. (1994). Geochemistry, groundwater and pollution. Balkema, Rotterdam.
2. Beven, K. J. (2002). The Future of Distributed Modelling - Special Issue. Hydrological Processes, 16, 169-172.
3. Beven, K..J. (2004). Rainfall-runoff modelling. The primer, Wiley.
4. Chadwick, A.; Morfett, J.C.; Borthwick, M. (2004). Hydraulics in Civil and Environmental Engineering. 4th Edition,Taylor & Francis.
5. Chaudry, M.H. (1993). Open channel flow. Prentice Hall.
6. Domenico P.A.; Schwartz, F.W. (1990). Physical and Chemical Hydrogeology, John Wiley & Sons.
7. Fank, J.; Rock, G. (2005). Tracer Experiments on Field Scale for Parameter Estimation to calibrate Numerical Transport Models. In: Nützmann, G.; Viotti, P.; Aagaard, P. (eds), Reactive Transport in Soil and Groundwater - Processes and Models, 239-250, Springer, Berlin – Heidelberg – New York.
8. Fetter, C.W. (1998). Contaminant Hdrogeology. 2nd ed., Prentice Hall, Inc.
9. Fisher, H.B. (1979). Mixing in Inland and Coastal Waters. Academic Press.
10. Helmig, R. (1997). Multiphase Flow and transport Processes in the Subsurface. Springer.

11. Ji, Z..G. (2008). Hydrodynamics and water quality – Modeling rivers, lakes and estuaries. Wiley.
12. Józsa, J. (2004). Shallow lake hydrodynamics: Theory, measurement and model applications. Lecture notes of the IAHR Short Course on Environmental Fluid Mechanics, Budapest, 7-16 June.
13. Krámer, T.; Józsa J (2007). Solution-adaptivity in modelling complex shallow flows. Computers & Fluids. 36(3): 562-577.
14. Rausch, R.; Schäfer, W.; Therrien, R. (2005). Solute Transport Modelling (Borntraeger).
15. Schäfer, D.; Schäfer, W.; Kinzelbach, W. (1998). Simulation of reactive processes related to biodegradation in aquifers: 1. Structure of the three-dimensional reactive transport model. J Cont Hydr 31:167-186.
16. Simons, T.J. (1980). Circulation models of lakes and inland seas. Canadian Bulletin of Fisheries and Aquatic Sciences No. 203, Ottawa.
17. Singh, V.P. (1988). Hydrologic systems: Rainfall-runoff modeling. Prentice Hall.
18. Szilagyi J.; Parlange, M. B. (1999). A geomorphology-based semi-distributed watershed model. Advances in Water Resources 23, 177-187.
19. Zheng, C.; Bennet, G.D. (1995). Applied contaminant transport modelling. Van Nostrand Reinhold, A Divison of International Thompson Publishing Inc.

QUALITY ASSURANCE METHODS:

An anonymous questionnaire will be filled in by all of the course participants. This procedure is compulsory for all subjects and is aimed at evaluation both of the teacher's performance (quality of delivery) and of the overall content and structure of the course.

15.02.2011, Sem

Joint Doctoral Programme “Geo-Engineering and Water Management”	
POSTGRADUATE STUDY:	Joint Doctoral programme Geo-Engineering and Water Management
COURSE TITLE:	**HYDROGEOCHEMISTRY**
COURSE STATUS:	Optional course (OW 1)
LECTURER’S	**Martin Dietzel, Sanja Kapelj, Branka Trček**

COURSE DESCRIPTION:

The course will be an introduction to aqueous geochemistry and isotope hydrology. Emphasis is placed on using the chemical and isotopic properties of water, and their spatial distribution, as a means of investigating water transport on and below the earth's surface. The fundamentals of both stable and radiogenic isotope systems used in the geosciences and their relevance to hydrogeologic processes, fluid rock interaction and climate will be discussed. The effects of changing geochemical conditions caused by rock/water interactions, landfills, wastewater, injection wells, mine tailings, etc. on groundwater quality will be introduced. Methods of water sampling in the field will be presented. Lectures on hydrophysics (isotope hydrology) will include an overview of the concepts of stable and radioactive isotopes and their application to solving practical problems such as determination of the sources of ground-water and surface-water, isotope hydrograph separations, recharge rate, ground-water dating, geochemical behavior of selected isotopes, verification of hydrologic flow models, sources of contaminants, and paleoclimatology. Besides the key role of isotope and geochemical techniques in understanding the flow patterns of the groundwaters, the course will provided basic information on chemical and isotopic analytical techniques, managing water quality data and geochemical modelling.

- Introduction – history evolution, connection with other scientific fields and application
- Universe and the Earth – genesis, geochemical differentiation of elements, water on the Earth and hydrologic cycle
- Composition, properties and formation of soils – weathering processes and alteration of rocks and minerals, physical properties of soil, chemical composition of soil, geochemical reactions in soil, transport of substances and contamination in the soil, pedological classification, legislation and regulation of quality
- Chemical analysis od soil - sampling procedures and equipment, determination of soil composition, physical and chemical properties of soil – total and sequential analysis of soil, basic analytical techniques and methods – rengen diffraction analysis, X ray fluorescence, atomic emission spectrometry, atomic emission spectrometry with induced plasma, quality control)
- Basic principles of hydrogeochemistry – formation of chemical composition of natural waters, precipitation, surface and groundwater composition; physical and chemical properties of water, isotope composition, thermodynamical equilibria in water solution; dissolution of gases, liquids and solids, fractionation, difussion and osmoses, vapour pressure, dissolution of electrolyte, chemical kinetics and equilibrium, dissociation of water and pH, equilibrium in solutions of acids and bases, buffer solutions, hydrolisis of salts; carbonate equilibrium (dissolution and precipitation, water hardness, open and closed systems of carbonate dissolution, dolomite dissolution): stability of primary silicates and weathering products (kinetics of weathering, mass balance, precipitation and dissolution); redox reactions (redox equilibrium, stability of dissolved ionic species, gasses and minerals – Eh-pH diagrams – pyrite oxidation; oxidation and reduction of ionic species of nitrogen, sulphur and iron); basic colloid chemistry, ionic exchange, chemical composition of natural waters (gases, main ions, biogene substances, microelements – heavy metals, organic matter)
- Sampling and analysis of surface and groundwater samples – procedures and equipment for water sampling; field and laboratory measurement techniques, preparation methods and analytical determinations in laboratory, quality control, quality water standards, legislative and regulative about water quality
- Natural radioactive and stable isotopes in soils, surface and groundwater – origin, geochemistry, application in water and soil studies -^{14}C, ^{3}H, ^{18}O, D, ^{13}C, ^{34}S, ^{15}N
- Connection between rocks, soils and composition of surface and ground waters – geotechnical and hydrotechnical aspects of geochemistry application (determination of water origin, influence of chemistry on geotechnical and hydrotechnical object and opposite, natural and anthropogenic changes of properties of materials, rocks, sediments and soils caused by geochemical processes); influence of human activity on quality of soil, surface and groundwater (agriculture, industry, acid rains, application soil and water geochemistry in studies of groundwater resources and its protection – ecological studies, hydrogeological studies, specific vulnerability evaluation, risk assessment)

- Geochemical modelling – speciation models, mass balance models, reaction-path models, modelling of mixing of waters of different origin and composition, simulation of some contamination behaviour etc.

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES (*max. 500 characters – describe main goal of the subject in terms of knowledge and skills that a student would acquire by taking the course*):

Hydrophysics and hydro(geo)chemistry are essential for solving problems related with (ground)water quality and hydrology, hydrogeology and water management. The course will develop competence in the following fields: sampling and analysis of (ground)water; thermodynamics and kinetics of hydrogeochemical processes; reactive properties of hydrogeological systems; carbonate chemistry; weathering of silicates; redox-processes; effects of evaporation and mixing of different water types; isotope hydrology, numerical geochemical modelling.
The lectures (subject, tuition) deals with an application of hydrogeochemistry in studies of influence of water and soil in geotechnical engineering, hydrotechnic engineering, studies of groundwater and surface waters and its protection. During the course students will be detail instructed about theoretical basis of hydrogeochemistry as well as research methods and techniques, specially attributed on common and individual work of students
Methods and techniques of apply hydrogeochemical study (sampling, sample conservation, storage and preparation, measurements, interpretation), geochemical modelling
Tuition will include permanent examination of adopted knowledge throughout the mid-term exams, practical laboratory and field work, seminar works.

RECOMMENDED LITERATURE (*with detailed data on publisher and year of publication*):

1. Appelo, C.A.J.; Postma, D. (2005. Geochemistry, Groundwater and Pollution. Completely revised 2nd Edition Balkema Publ.
2. Clark, I.; Fritz, P. (1997). Environmental Isotopes in Hydrogeology, Lewis Publishers, Boca Raton.
3. Kendall, C.; McDonell, J.J. (eds.) (1998),. Isotope Tracers in Catchment Hydrology, Elsevier Science.
4. Stumm, W.; Morgan, J.J. (1996). Aquatic Chemistry, Chemical Equilibria and Rates in Natural Waters. 3rd ed, John Wiley & Sons, Inc., New York.

Obligatory literature / prepared textbook- lectures; chapters in:

1. Appelo, C.A.J.; Postma, D. (1994, 1997). Geochemistry, groundwater and pollution. Balkema, Rotterdam.
2. Boulding, R.J. (1995). Practical Handbook of Soil, Vadose Zone and Groundwater Contamination - Assessment, Prevention, and Remediation. Lewis Publishers.
3. Drever, J.I. (1997). The geochemistry of natural waters. Surface and groundwater Environments. Prentice Hall Inc., Upper Saddle River.
4. Fritz.P.; Fontes, J.C. (eds.) (1980). Handbook of Environmental Isotope Geochemistry. Elsevier, Amsterdam.
5. Kendall, C.; McDonenell (1998). Isotope tracers in catchment hydrology. Elsevier.
6. Parkhurst, D.L. (1995). PHREEQC - computer program for speciation, reaction-path, advective-transport and inverse geochemical calculations. Water-Resources Investigations Report 95-4227, USGS, Colorado.
7. Plummer, L.N.; Prestemon, E.C.; Parkhurst, D.L. (1994). An interactive code (NETPATH) for modelling net geochemical reactions along flow path, Version 2.0. USGS Water-Resources Investigation Report 94-4169, Reston, Virginia.
8. Sparks, D.L. (2003). Environmental Soil Chemistry. Academic Press, an imprint of Elsevier.
9. Standard methods for the examination of water and waste water (2005) . APHA, Washington DC.

Recommended literature; chapters in:

1. Biondić, B.; Bakalowitz, M.; Zwalen, F.; Almeida, O.; Hoetzl, H. (1995): Hydrogeological aspects of groundwater protection in karstic area. EU COST ACTION 65, Project, EU, Brussels.
2. Biondić, B.; Biondić, R.; Kapelj, S. (2006). Protection of the karst aquifers in the river Kupa catchment area and sustainable development. Environmental Geology (on-line).
3. IAEA (1981). Stable Isotope Hydrology. Technical Report Series No. 210, Vienna.
4. IAEA (1983). Guidebook on Nuclear Techniques in Hydrology. Techical report series No. 91, IAEA, Vienna.
5. Zwahlen, F. (ed.) (2004). Vulnerability and risk mapping for the protection of carbonate (karst) aquifers. Final report – COST Action 620. European Commision, Office for Official Publications of the European.

QUALITY ASSURANCE METHODS:

An anonymous questionnaire will be filled in by all of the course participants. This procedure is compulsory for all subjects and is aimed at evaluation both of the teacher's performance (quality of delivery) and of the overall content and structure of the course.

15.02.2011,Sem

Joint Doctoral Programme "Geo-Engineering and Water Management"	
POSTGRADUATE STUDY:	Joint Doctoral Programme Geo-Engineering and Water Management
COURSE TITLE:	**VULNERABILITY, HAZARD AND RISK ASSESSMENT**
COURSE STATUS:	Optional course (OW 2)
LECTURER'S	**Božidar Biondić, Hans Zojer, Branka Trček**

COURSE DESCRIPTION:

Criteria for vulnerability, relation to EU-WFD, Intrinsic vulnerability regarding European approach, Specific vulnerability regarding properties of contaminants, Hazard potentials: definition and mapping of hazard zones, rating and weighting, GIS-supported interpretation, Risk analysis, Vulnerability methodologies: PI-method, VULK-method, COP-method, VURAAS-method, Comparison of different methods
Vulnerability, hazard and risk assessment is one of the most important hydrogeological activity in the field of water resources protection, especially groundwater. It's the base for the physical and urban planning and generally land use. Vulnerability mapping can be divided in two main groups: intrinsic and specific
Intrinsic vulnerability uses four main factors: overlying layers (O), concentration of flow (C), karst network development (K), precipitation regime (P) Specific vulnerability is directed to a particular contaminant or group of contaminants. There are two main environmental parameters, which can influence on the specific vulnerability – hydraulic properties and physical and chemical properties of layers and related processes. Hazard is defined as potential source of contamination of anthropogenic origin – different type of hazard. Risk assessment is a term used to denote the probability of suffering harm from a hazard. Risk assessment identifies the existing or potential hazards and exposure pathway of contamination that need to be addressed in other to provide the basis for taking action to ensure groundwater protection. Usage of GIS methods for mapping and risk assessments.

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES (*max. 500 characters – describe main goal of the subject in terms of knowledge and skills that a student would acquire by taking the course*):

Instrument for a better transfer of EU-Water Framework Directive WFD, Movement from source protection to resource protection, Development of data collection sheet
This is very important hydrogeological research activity, which has to be applied in water resources protection. The candidate will become more familiar with the applying of GIS, aerial and satellite images in water protection, and accept the European approach of water protection in their future research and scientific activity.

RECOMMENDED LITERATURE (*with detailed data on publisher and year of publication*):

1. Cichocki, G.; Zojer, Ht.; Zojer, H. (2001). Karstwasserschutz und Vulnerabilität. Entwicklung eines Modells in den Karnischen Alpen. Mitt. IAG, Universität für Bodenkultur, Wien.
2. COST 65 (1995). Hydrogeological aspects of groundwater protection in karst areas. Final report, European Comission, Directorate – General XII Science, Research and Development, Report EUR 16547 EN, Brussels, Luxemburg.
3. COST 620 (2004). Vulnerability and risk mapping for the protection of carbonate (karst) aquifers. Final report. European Comission, Directorate General for Research, Report EUR 20912, Brussels, Luxemburg.
4. Daley, D.; Dassagues, A.; Dunne, S.; Goldscheider, S.; Neale, N.; Popescu, I.; Zwahlen, F. (2002). Main concepts of the European Approach for groundwater vulnerability assessment and mapping. Hydrogeol. Journal, 10/2.
5. Jeanin, P.Y.; Cornaton, F.; Zwahlen, F.; Perochet, P. (2001). A tool for intrinsic vulnerability assessment and validation. Proc. Conf. Limest. Hydrol. and Fiss. Media, Besancon.
6. Vrba, J.; Zaporožec, A. (1994). Guidebook on Mapping Groundwater Vulnerability. International Contributions to Hydrogeology (IAH), 16, Hannover.
7. Zwahlen, F. (ed.) (2004). Vulnerability and risk mapping for the protection of carbonate (Karst) aquifers. COST Action 620, European Commission, Brussels.

QUALITY ASSURANCE METHODS:

An anonymous questionnaire will be filled in by all of the course participants. This procedure is compulsory for all subjects and is aimed at evaluation both of the teacher's performance (quality of delivery) and of the overall content and structure of the course.

15.02.2011. Sem

Joint Doctoral Programme "Geo-Engineering and Water Management"	
POSTGRADUATE STUDY:	Joint Doctoral Programme Geo-Engineering and Water Management
COURSE TITLE:	**WATER TREATMENT AND ARTIFICIAL RECHARGE**
COURSE STATUS:	Optional course (OW 3)
LECTURER'S	**Harald Kainz, Hans Zojer**

COURSE DESCRIPTION:

This course will give an overview of physical, chemical and biological basics and state-of-the-art methods in water treatment and artificial water recharge. Focus will be laid on the following points:

- Reasons for water treatment and artificial recharge
- Legal requirement for drinking water (national and European requirements)
- Drinking water quality: Microbiological parameters, Chemical and physical parameters
- Methods of water treatment: Physical treatment, Chemical treatment, Biological treatment
- Procedural steps in water treatment: Sieving, Sedimentation, Chemical stabilisation, Iron and manganese removal, Precipitation, Flocculation, Filtration (slow and high rate sand filtration), Membrane technologies in water treatment, Adsorption, Disinfection, Gas and Ionic treatment, Stripping
- Artificial groundwater recharge: Options for artificial recharge, Fractured aquifers providing row water for artificial recharge, Artificial recharge in granular sediments, Coastal aquifers, Artificial recharge technology processes, Infiltration methods and system designs, Source water assessment, Operation and maintenance
- Examples for water treatment and artificial recharge: Karst water, Groundwater, Surface water from lakes and rivers, Artificial recharge in a fractured aquifer (Iran), Graz water supply, Strategies for coastal aquifer management, Greece

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES (*max. 500 characters – describe main goal of the subject in terms of knowledge and skills that a student would acquire by taking the course*):

After completing this course students will understand the requirements for drinking water in regard to physical, chemical and microbiological aspects. They will have understood methods and procedural steps in state-of-the art water treatment.

Furthermore they will be familiar with the principles of artificial groundwater recharge depending on

- hydrogeological conditions for the recharge
- source of raw water
- purpose of groundwater use

RECOMMENDED LITERATURE (*with detailed data on publisher and year of publication*):

1. Kainz, H.; Kauch, P. (2007). Siedlungswasserbau und Abfallwirtschaft, Manz Verlag.
2. Kainz. H. (2008). Wasseraufbereitung. Vorlesungsunterlagen, Institut für Siedlungswasserwirtschaft und Landschaftswasserbau , Technische Univ.iversität Graz.
3. Technische Univiversität Graz; Univiversität für Bodenkultur Wien; Universität der Bundeswehr München (2008). Optimierung bestehender Aufbereitungsanlagen für huminstoffreiche Wässer im Waldviertel, Pilotversuch der Stadtgemeinde Heidenreichstein.
4. Zojer, H.; Emblanch, E.; Fidelibus, D.; Hertilendi, E.; Kogovsek, J. (2005). Environmental tracing for outlining fresh groundwater flow in coastal karstic aquifers. In: Groundwater management of coastal karstic aquifers, Tulipano, L.: Fidelibus, D.; Panagopoulus, A. (eds), COST Action 621, European Commission, Brussels.
5. Zojer, H. (2007). Sustainable development of water management in semiarid regions by means of artificial groundwater recharge and harvesting. Proc. Mitigation of Water Stress in Coastal Zones, Barcelona.
6. Zojer, H. (2008). Artificial groundwater recharge, an essential technology to overcome water scarcity in semiarid regions. Strategic paper for the Water Supply and Sanitation Technology Platform (WSSTP), European Commission, Brussels.

QUALITY ASSURANCE METHODS:

An anonymous questionnaire will be filled in by all of the course participants. This procedure is compulsory for all subjects and is aimed at evaluation both of the teacher's performance (quality of delivery) and of the overall content and structure of the course.

15.02.2011, Sem

Joint Doctoral Programme "Geo-Engineering and Water Management"	
POSTGRADUATE STUDY:	Joint Doctoral Programme Geo-Engineering and Water Management
COURSE TITLE:	**WATER SUPPLY AND DISTRIBUTION**
COURSE STATUS:	Optional course (OW 4)
LECTURER'S	**Renata Jecl, Harald Kainz**

COURSE DESCRIPTION:

This module aims to provide a basic knowledge of classical and contemporary problems in the management of water supply and distribution systems for the practising engineer. It also offers practical experience in using water supply and distribution modelling tools. The main objective of this module is to provide students with the latest information and knowledge in the area of water supply and distribution system management. Specific objectives are to provide students with the best practice on how to model each system component (from source to tap), build and calibrate the overall water supply and distribution system models (both quantity and quality), use these and other models to plan a day-to-day system operation, use these and similar models for the long-term system planning and management, including system rehabilitation/expansion, address some advanced issues related to system planning and management, including issues of reliability, risk and uncertainty.

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES (*max. 500 characters – describe main goal of the subject in terms of knowledge and skills that a student would acquire by taking the course*):

At the end of this module, students will have acquired understanding of water supply and distribution system components, their characteristics and functioning of such systems, have acquired basic knowledge of water supply and distribution system management problems, be able to make appropriate and critical use of water supply and distribution modelling and management principles, be able to identify, formulate and analyse a management problem in a given water supply/distribution system, be able to critically assess research results, have acquired some practical experience of using water supply/distribution modelling tools.

RECOMMENDED LITERATURE (*with detailed data on publisher and year of publication*):

1. Bruce, E.; Larock et al. (2000). Hydraulics of Pipeline Systems, CRC Press, Boca Raton.
2. Fair; Geyer; Okun (1966). Water and Wastewater Engineering (Vol. 1 - Water Supply and Wastewater removal). John Wiley & Sons.
3. Orlob, G.T. (1983). Mathematical modeling of water quality: streams, lakes, and reservoirs. John Wiley, Chichester.
4. Walsky, T. et al. (2006). Advanced Water Distribution Modeling and Management, Haestad Methods Solutions. Bentley.

QUALITY ASSURANCE METHODS:

An anonymous questionnaire will be filled in by all of the course participants. This procedure is compulsory for all subjects and is aimed at evaluation both of the teacher's performance (quality of delivery) and of the overall content and structure of the course.

15.02.2011, Sem

Joint Doctoral Programme "Geo-Engineering and Water Management"	
POSTGRADUATE STUDY:	Joint Doctoral Programme Geo-Engineering and Water management
COURSE TITLE:	**MONITORING SYSTEMS AND GIS**
COURSE STATUS:	Optional course (OW 5)
LECTURER'S	**Ranko Biondić, Hans Zojer**

COURSE DESCRIPTION:

Remote Sensing is the science of acquiring information about the earth's surface without being in contact with it. Satellite Remote Sensing is becoming a fundamental space technology for the efficient management and monitoring national and trans-boundary water resources.
This course is addressed for those who want to understand the basics of both GIS and Remote Sensing including the instrument capabilities and limitations, and how the data can be processed and implemented to carry out environmental studies.
The first part of the course will cover the principles of GIS and Remote Sensing, including radiation theory, sensor systems, data acquisition, storage, and analysis. The second part of the course will deal with the application of Remote Sensing principles and data to "real world" projects.
Monitoring environmental changes using satellite imagery should improve our abilities to assess the human and natural impact on the ecosystem and where necessary for developing better management practices to improve water use and water quality.

What is GIS?, GIS - Historical overview, Advantages of GIS, GIS components, Hardware for GIS, GIS Software, Different data types and their differences, Standardization for working in GIS and need for Guidelines, Making and using of symbols for spatial data viewing, Database building (structures,...), Joining of spatial data with database, Mobile GIS (GPS, PDA, laptop computers, field work), Using of remote sensing (coastal aquifers hydrogeology, flood control, geology and tectonics), Modelling (Spatial Analyst, 3D Analyst), Cartography, GIS for end user (ArcView application)
Teaching methods: Theory base of GIS, Practical work in GIS tools in computer room__>Practice of preparation of hydrogeological maps, Field work together with course "Karst hydrogeology and protection of karst aquifers" (collection of data, GPS, preparing a GIS for the end user)

Methodological aspects of hydrological investigations in the framework of the hydrological cycle and especially the drinking water protection; introduction to hydrological measurement techniques (geological and anthropological aspects); principles of sensors and basics of sensor technology, loggers and applications; quality control of drinking water (indicators, parameters, limit values and deduction limits);; basics of measurement engineering (accuracy, error, digitalization, margin of error); network design (structures and possibilities of communication, mono- and bidirectional communication; security of data transfer, redundancy of hardware and data); environmental impacts to network-communication; interfaces to www; integration of measuring networks to early warning systems and decision support systems; measuring networks and hydrogeological investigations (time series generation, event monitoring); security aspects of data collection and transfer.

The up-to-date techniques and instrumentation to collect river and lake bathymetry, flow velocity, sediment transport, bed materials data with various space and time resolution. Monitoring of hydromorphology as required by the EU WFD. Automated techniques, optimising measurement sites and periods in order to maximise data information content. Methods and tools relevant to fluvial and lake conditions and scales (including e. g. the wind as external forcing factor). Computer analysis, evaluation and displaying methods as well as the ways to utilise the data in numerical model calibration and verification.

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES (*max. 500 characters – describe main goal of the subject in terms of knowledge and skills that a student would acquire by taking the course*):

This course introduces the combination of both GIS and Remote Sensing as important technologies to further our understanding of Earth's land, atmospheric, and water processes. Students study remote sensing science, techniques, and satellite technologies to become familiar with the types of information that can be obtained and how this information can be applied in the natural and social sciences.

Application of Geographic Information Systems in water resources management is today obliged tool for multilayer interpretations necessary for appropriate interpretations. The aim of this course is to introduce students with advantages of GIS in water resources management and to train them in computer room in basic operations with GIS tools.

Skills after the course: Knowledge of the basics about measurement techniques, sensor technology with emphasis to quality control of drinking water and measurement engineering; ability of analyzing existing measuring networks and designing plain new networks, principles of sensor application to the respective aim; knowledge of possible communication structures and implementation; basics of data presentation and possibility of access in the world wide web, considering also security aspects.

This module develops specific capacities in the area of advanced hydrometry and data analysis in surface waters, including automated, various space-time resolution techniques.

RECOMMENDED LITERATURE (*with detailed data on publisher and year of publication*):

1. Biondić, B. et al.: Hydrogeological map of the Republic of Croatia (S 1:300.000)
2. Boiten, W. (2000). Hydrometry. 2nd Edition. Taylor & Francis.
3. Drury, S.A. (2001). Image Interpretation in Geology.
4. ESRI. Arc/Info users manuals (PDF format).
5. ITC. Ilwis 3.1 users manual.
6. Jensen, J.R. (2006). Remote Sensing of the Environment an Earth Resource Perspective.
7. Lillesand, T.M.; Kiefer, R.W. (2003). Remote Sensing and Image Interpretation. 5th Edition.
8. Oluić (2001). Snimanje i istraživanje zemlje iz svemira. HAZU & GEOSAT, Zagreb.
9. Scharl, A. (2004). Environmental Online Communication. Springer, London, Berlin.
10. Schultz, G.A.; Engman, E.T. (2000). Remote Sensing in Hydrology and Water Management
11. Strangeways, I. (2003). Measuring the Natural Environment. Cambridge University Press, Cambridge, 4.
12. U.S. Bureau of Reclamation (2006). Erosion and Sedimentation Manual. Available online at www.usbr.gov.
13. Western, A.W.; Grayson, R.B.; Costelloe, J.F. (2006). Prnciples of hydrological measurements. Encyclopaedia of Hydrological Sciences. Part 1. Theory, organization and scale. Wiley.

QUALITY ASSURANCE METHODS:

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16.02.2011, Sem