



1. GENERAL INFORMATION

Study programme title	Graduate study: Geological Engineering				
Course title	Groundwater protection		Semester	II.	
Teacher	Prof. Zoran Nakić, PhD		Course code	27371	
Course type	<input checked="" type="checkbox"/> obligatory <input type="checkbox"/> elective		ECTS	5	
Location	University of Zagreb, Faculty of mining, geology and petroleum engineering, Pierottijeva 6, Zagreb, Croatia				
Language	<input type="checkbox"/> Croatian <input checked="" type="checkbox"/> English				
Class type	Weekly hours	Teaching staff	Office hours	Room	E-mail
Class	2	Prof. Zoran Nakić	Tuesday 8-10 a.m.	V404	zoran.nakic@rgn.hr
Practice	2	Assistant Laura Bačani	Friday 9-11 a.m.	V710	laura.bacani@rgn.hr
Field lecture					
E-learning level	1	Percentage of on-line class (max. 20%)		5%	

2. COURSE DESCRIPTION

Course aims	The aim of the course is to provide students with basic knowledge about: 1. the political, sociological and legal aspects of groundwater protection, 2. procedures and methods of groundwater protection, 3. groundwater protection methods, 4. groundwater modeling in the function of their protection, 5. methods of purification and remediation of groundwater contamination.
Requirements for applicants	
Programme level learning outcomes with course contribution	1. To construct conceptual models of groundwater systems 2. To model processes in groundwater systems 3. To apply groundwater protection concepts
Expected course level learning outcomes (4-10 outcomes)	1. To apply modern approaches and concepts of groundwater protection in addressing the specific

	<p>problems of groundwater protection at national, regional and local level</p> <ol style="list-style-type: none"> 2. To analyse usable and non-usable groundwater functions for the purpose of identifying the conceptual framework for evaluation and protection of groundwater 3. To analyse measures and instruments for groundwater protection 4. To apply flow simulation and contaminant transport methods in determining the sanitary protection zones 5. To combine different methods for determining the sanitary protection zones 6. To analyse the applicability of the remediation method of polluted water systems in specific hydrogeological conditions and depending on the characteristics of pollutants
Course contents by individual lessons	
Class	Practice
P1 - Introduction to the course, natural characteristics of groundwater systems in the Republic of Croatia, groundwater quality, characteristic sources of groundwater contamination	V1 - Introductory exercises: groundwater systems, hydrogeological parameters
P2 - Approach to groundwater protection in accordance with EU directives and guidelines, development of the legal framework for groundwater protection in EU countries, Water Framework Directive and daughter directives	V2 - EU legislation on groundwater protection: similarities, differences and disadvantages
P3 - Legislative framework for the protection of groundwater systems in the Republic of Croatia, strategies, laws and subordinate acts in the function of groundwater protection	V3 - Legislative regulations of the Republic of Croatia related to the protection of groundwater: similarities, differences and disadvantages
P4 - Groundwater protection levels, protection of strategic groundwater resources: categorization, regulatory framework and protection measures	V4 - International FP7 Project GENESIS: Examination of Public Opinion on the Status of Zagreb Aquifer - Results and Conclusions
P5 - Spatial planning in the function of groundwater protection; the significance of spatial planning documentation, strategic documents for spatial planning, examples of integrating protected areas for potable water into spatial plans and documents	V5 - Spatial plans and groundwater protection



P6 - Groundwater valuation, conceptual framework for valuation, use and non-use functions of groundwater	V6 - Review of typical examples of sanitary protection zones in spatial plans - problems and disadvantages
P7 - Groundwater measures and instruments - basic and supplementary measures; regulatory, economic, self-regulatory and institutional instruments, the legislative framework for the application of measures and instruments of protection	V7 – First colloquium
P8 - Groundwater source protection zones - criteria and methods for determining sanitary protection zones, natural and specific vulnerabilities of groundwater	V8 - Sanitary protection zones, natural and specific vulnerability of aquifers - description of the methods
P9 - Ordinance on conditions for determining groundwater source protection zones; examples of the determination of the sanitary protection zones in rocks with intergranular and fissure (karstic) porosity	V9 - Examples of methods for determining sanitary protection zones - Part 1
P10 - Application of analytical, semi-analytic and numerical methods in determination of sanitary protection zones, examples from practice	V10 - Examples of methods for determining sanitary protection zones - Part 2
P11 - Application of different methods of determining natural and specific vulnerabilities for the purpose of groundwater protection; examples from practice	V11 – Creating vulnerability map using the GOD method: The thematic layer of "aquifer type" and the thematic layer "aquitard thickness"
P12 - Protection of exploitation wells and springs: criteria for the location of wells, design and construction of wells with safe materials, disinfection of wells and water supply systems	V12 – Creating vulnerability map using the GOD method: The thematic layer of the "lithological characteristics of the aquifer" and the thematic layer of "depth to groundwater"
P13 – Visit to the “Mala Mlaka” wellfield in the City of Zagreb	V13 – Visit to the “Mala Mlaka” wellfield in the City of Zagreb
P14 - Methods and techniques for remediation of groundwater pollution: localization measures to prevent the spread of pollutants; measures to remove contaminants from the underground	V14 – Creating the final vulnerability map using the GOD method
P15 - Presentation of seminar papers by students	V15 - Presentation of seminar papers by students



Students' obligations				
Students' work track <i>(indicate share in ECTS points for each activity so that overall ECTS number corresponds to class credits score):</i>	Class attendance	2	Research	0,5
	Project		Report	
	Colloquium	0,5	Seminar paper	1
	Practical work		Oral exam	1
	Written exam		(Extra)	
Type of exam, grades and evaluation of students work during class and on final exam	Evaluation through two colloquia, seminar work, homework and oral exam			
Mandatory literature (available in the Library and via other media)	Teaching script, EU directives, sectoral strategies (Water Management Strategy, Spatial Planning Strategy), acts and ordinances, professional and scientific papers from journals,			
Additional literature (at the moment of study program proposition application)	Mayer, D. (1993): Kvaliteta i zaštita podzemnih voda, Hrv. društvo za zaštitu voda, Zagreb			
	Tedeschi, S (1997): Zaštita voda, Hrv. Društvo građ. inženjera., Zagreb			
Examination terms	Tuesday or Wednesday within exam terms (at 9 a.m.)			
Other	-			