UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

Course guide
250341 - ENGGEOAMB - Geoenvironmental Engineering

Last modified: 16/11/2022

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: BACHELOR'S DEGREE IN GEOLOGICAL ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2022 **ECTS Credits:** 6.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: MAARTEN WILLEM SAALTINK

Others: MAARTEN WILLEM SAALTINK

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
4026. Ability to apply methodologies for studying and assessing environmental impact, and, in general, environmental technologies, sustainability and waste disposal
4032. Design, planning and execution of projects for prospecting for and extracting minerals, rocks, fossil and nuclear fuels, and groundwater, and geotechnical projects. Students will learn to design, plan and carry out fluid injections into underground structures.
4033. (ENG)Capacitat de desenvolupament i selecció d'eines de prospecció i extracció de recursos naturals així com per la injecció de fluids en estructures subterrànies.
4040. Hydrological, hydrogeological, stratigraphic and palaeontological studies.

Generical:
3103. Students will learn to identify, formulate and solve a range of engineering problems. They will be expected to show initiative in interpreting and solving specific civil engineering problems and to demonstrate creativity and decision-making skills. Finally, students will develop creative and systematic strategies for analysing and solving problems.
3106. Students will learn to assess the complexity of the problems examined in the different subject areas, identify the key elements of the problem statement, and select the appropriate strategy for solving it. Once they have chosen a strategy, they will apply it and, if the desired solution is not reached, determine whether modifications are required. Students will use a range of methods and tools to determine whether their solution is correct or, at the very least, appropriate to the problem in question. More generally, students will be encouraged to consider the importance of creativity in science and technology.
3107. Students will learn to identify, model and analyse problems from open situations, consider alternative strategies for solving them, select the most appropriate solution on the basis of reasoned criteria, and consider a range of methods for validating their results. More generally, students will learn to work confidently with complex systems and to identify the interactions between their components.
3109. Students will learn to plan, design, manage and maintain systems suitable for use in civil engineering. They will develop a systematic approach to the complete life-cycle of a civil engineering infrastructure, system or service, which includes drafting and finalising project plans, identifying the basic materials and technologies required, making decisions, managing the different project activities, performing measurements, calculations and assessments, ensuring compliance with specifications, regulations and compulsory standards, evaluating the social and environmental impact of the processes and techniques used, and conducting economic analyses of human and material resources.
3112. Students will develop an understanding of the different functions of engineering, the processes involved in the life-cycle of a construction project, process or service, and the importance of systematising the design process. They will learn to identify and interpret the stages in preparing a product design specification (PDS), draft and optimise specifications and planning documents, and apply a systematic design process to the implementation and operation phases. Students will learn to write progress reports for a design process, use a range of project management tools and prepare final reports, and will be expected to show an awareness of the basic economic concepts associated with the product, process or service in question.
3113. Students will learn to identify user requirements, to draft definitions and specifications of the product, process or service in question, including a product design specification (PDS) document, and to follow industry-standard design management models. Students will be expected to show advanced knowledge of the steps involved in the design, execution and operation phases and to use the knowledge and tools covered in each subject area to the design and execution of their own projects. Finally, students will assess the impact of national, European and international legislation applicable to engineering projects.

Transversal:
586. ENTREPRENEURSHIP AND INNOVATION - Level 2. Taking initiatives that give rise to opportunities and to new products and solutions, doing so with a vision of process implementation and market understanding, and involving others in projects that have to be carried out.
589. SUSTAINABILITY AND SOCIAL COMMITMENT - Level 2. Applying sustainability criteria and professional codes of conduct in the design and assessment of technological solutions.
594. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
584. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

TEACHING METHODOLOGY

According to the termination schedule of the Degree in Geological Engineering, there is no ordinary teaching any more. There will only be exercises and exams.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

LEARNING OBJECTIVES OF THE SUBJECT

Students will acquire an understanding of the basic concepts in geoenvironmental engineering (groundwater geochemistry, reactive transport, contaminated soils) and learn to conduct environmental management studies.

Upon completion of the course, students will be able to: 1. Use analytical and numerical methods to analyse contaminant transport in groundwater;
2. Conduct a geochemical environmental study taking into account the phases of the water cycle;
3. Conduct a multidisciplinary geo-environmental study.

Contamination; Toxicology; Dosage; Epidemiology; Environmental risk; Risk assessment; Contaminant transport; Advection, diffusion, dispersion, reactions, adsorption; Transport equation; Thermodynamics: Reaction types; Thermodynamic functions; Chemical potential; Activity; Law of mass action; Mixtures; Gases; Solutes; Reaction time and transport time; Reactive transport; Stoichiometric matrix; Component matrix; Transport equations; Aquifer contamination; Sources of contamination; Degradation processes; Decontamination systems; Point-source and diffuse soil contamination; Transport mechanism; Multiphase flow: Capillarity, wettability, characteristic curves; Soil decontamination; Contamination of rivers and reservoirs: Chemical oxygen demand; Streeter-Phelps equation; Control systems: Oxidation, stripping, photochemical reactions; Eutrophication; Nutrients; Carbon cycle; Wetlands; Impact of civil engineering; Waste management; Urban solid waste; Special waste; Radioactive waste; Landfill design; Environmental impact studies; Design, planning and implementation of fluid injections into underground structures

STUDY LOAD

Type	Hours	Percentage
Guided activities	6,0	4.00
Hours medium group	12,0	8.00
Hours large group	34,0	22.67
Self study	84,0	56.00
Hours small group	14,0	9.33

Total learning time: 150 h

CONTENTS

Theme 1: Transport of solutes

Description:
Principle of a mass balance, solution of ordinary differential equations.
Representative elementary volume (REV), scalar , vector and tensor fields, gradient, divergence.
Advection, diffusion and dispersion.
Formulation of the transport equation as a partial differential equation (PDE) and its solution using analytical solutions.
Examples of solving a problem using analytical methods.
Exercise 1 Solution
Balance in a cell, generic formulation of a numerical method, time integration, boundary conditions, types of methods, process of modeling, discretization, calibration.
Example of a numerical model.
Solution by the students of some problems by using a numerical model.
Saturation, capillarity, wettability, retention curve, unsaturated flow equation, non-aqueous phase liquids.
Exercise 2 Solution

Specific objectives:
To know how to formulate a mass balance of an integrated system and resolve it.
To knowing the mathematical concepts necessary for understanding other topics of the course.
To know the processes that transport pollutants in the atmosphere, surface water and subsurface.
To know how to formulate an EDP for the transport of a pollutant and how to solve it by analytical methods.
To understand what a numerical model does and know their capabilities and limitations.
To Know the relevant processes for the transport of non-aqueous phase liquids.

Full-or-part-time: 45h 36m
Theory classes: 10h
Practical classes: 4h
Laboratory classes: 5h
Self study : 26h 36m

Topic 2: Chemistry

Description:
Chemical equilibrium, thermodynamic definitions (system, phase, component, species) thermodynamic functions (enthalpy, entropy, Gibbs free energy, Nernst equation), chemical potential, activity, mass action law, mixtures of gases and liquids.
Equations and variables of speciation, pH-pe diagram, diagram of Sillen.
Practical examples of speciation.
Exercise 3 Solution
Functioning of a code for speciation.
Solution by the students of some problems with a code for speciation.
Reaction rate, elementary and global reactions, kinetic laws, kinetics of minerals, experimental determination.
Classification of biological metabolisms, redox sequence, kinetic laws, biological oxygen demand.
Mathematical formulation of reactive transport, components, stoichiometry.
Example of reactive transport.
Exercise 4 solution

Specific objectives:
To know the thermodynamic concepts necessary for understanding other topics of the course.
To know how to do chemical calculations assuming chemical equilibrium.
To Know how to use a code for speciation.
To know when to use a kinetic or equilibrium approach and how to work with kinetic laws.
To Understand the impact of biological processes.
To be able to integrate transport processes and chemical reactions and understand the difficulties, possibilities and limitations.

Full-or-part-time: 52h 48m
Theory classes: 11h
Practical classes: 6h
Laboratory classes: 5h
Self study : 30h 48m

Item 3: Cases of contamination and systems

Description:
Classification of contaminants, toxicological concepts.
Legal framework, environmental impact assessment, ecological footprint.
Factors and processes affecting soil and groundwater pollution, pollution cases.
Criteria, processes and methods remediation of soils and aquifers.
Causes, problems and remediation of acid mine drainage.
Transport equation in rivers and lakes / reservoirs, BOD and oxygen in rivers, eutrophication, reservoirs.
Wastewater treatment, first, seconded and third treatment, low cost systems.
Solution exercise 5
Stratification and atmospheric stability, calculation of plumes, air pollutants, air pollution cases.
Global carbon balance and energy, causes and effects of climate change solutions, carbon capture and storage.
Sources of waste disposal methods, urban waste management, hazardous waste and radioactive waste.
Exercise 6 solution

Specific objectives:
To introduce some chemical and toxicological concepts
To know the methodologies for studying and assessing the environmental impact.
To Know the relevant processes of contamination of soils and aquifers.
To know the methods of remediation for soils and aquifers.
To know the case of acid mine drainage.
To know the processes relevant to surface water pollution.
To know the processes and methods for wastewater treatment.
To know the processes relevant to air pollution.
To know the case of global warming.
Learn methods for treatment and waste management.

Full-or-part-time: 45h 36m
Theory classes: 12h
Practical classes: 3h
Laboratory classes: 4h
Self study : 26h 36m

GRADING SYSTEM

The evaluation is done through exams and marks for the exercises done at home. There are two exams, a first on topic 1, a second on all topics. Both have a short part with theoretical questions and a longer practical part in which they are asked to solve problems in the same style as those of the exercises done at home. In the theoretical part access to documentation (notes, books, etc.) is not allowed and in the practical part it is. The final mark is calculated using the following formula:
Nfin = 0.4 * Nec + 0.2 * Nex1 + 0.4 * Nex2
where Nfin is the final mark, Nec is the average mark of the exercises done at home, and Nex1 and Nex2 are the marks of the first and second exam. Qualification and admission criteria for reevaluation: Students who have failed in ordinary evaluation who have regularly taken the subject evaluation tests will have the option to do a reevaluation test in the period set in the academic calendar. The maximum mark in the case of doing the reevaluation exam will be five. In the case of justified absences during the ordinary evaluation period that have prevented examinations of part of the contents of a subject, and with the prior approval of the Head of Studies of the degree, the student may recover in the re-evaluation exam both that part of the subject that has not been previously evaluated as the one that has been suspended. The maximum grade limitation will not apply to first-time evaluated parties.

EXAMINATION RULES.

Failure to perform a laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

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BIBLIOGRAPHY

Basic:

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- B.J. Merkel; Planer-Friedrich, B. Groundwater geochemistry: a practical guide to modeling of natural and contaminated aquatic systems. 2nd ed. Berlin ; Heidelberg: Springer, 2008. ISBN 978-3-540-74667-6.
- Peavy, H.S.; Rowe, D.R.; Tchobanoglous, G. Environmental engineering. New York: McGraw-Hill, 1985. ISBN 0070491348.
- Stumm, W.; Morgan, J.J. Aquatic chemistry: chemical equilibria and rates in natural waters. 3a edición. New York: John Wiley and sons, 1996. ISBN 978-0-471-51185-4.
- Vallero, D.A. Fundamentals of air pollution [on line]. 4th ed. Oxford: Academic Press, 2007 [Consultation: 25/02/2021]. Available on: https://www.sciencedirect.com/science/book/9780123736154. ISBN 9780123736154.
- Valsaraj, K.T. Elements of environmental engineering: thermodynamics and kinetics. 3rd ed. Boca Raton, FL: CRC Press, 2009. ISBN 9781420078190.