# 250658 - CARGESTCAS - Characterization, Management and Treatment of Soil and Groundwater Contamination

**Coordinating unit:** 250 - ETSECCPB - Barcelona School of Civil Engineering  
**Teaching unit:** 751 - DECA - Department of Civil and Environmental Engineering  
**Academic year:** 2015  
**Degree:** MASTER’S DEGREE IN ENVIRONMENTAL ENGINEERING (Syllabus 2014). (Teaching unit Compulsory)  
**ECTS credits:** 5  
**Teaching languages:** Spanish, English

## Teaching staff
- **Coordinator:** FRANCISCO JAVIER SANCHEZ VILA  
- **Others:** DANIEL FERNANDEZ GARCIA, ALBERT FOLCH SANCHO, FRANCISCO JAVIER SANCHEZ VILA

## Opening hours
**Timetable:** To be agreed with the teachers, office D2-004.

## Teaching methodology
The course consists of 3 hours per week of classroom activity.  
The 2 hours are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.  
The 0.8 hours is devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.  
The rest of weekly hours devoted to laboratory practice.  
Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

## Learning objectives of the subject
- CE01 - Apply scientific concepts to environmental problems and their correlation with technological concepts.  
- CE04 - Identify, define and propose technological management and appropriate solution to an environmental problem.  
- CE05 - Dimension conventional treatment systems and raise their mass balance and energy.  

- Explore scientific concepts and technical principles of quality management of the receiving environments, atmosphere, water and soil.  
- Explore scientific concepts and technical principles of management and treatment of gaseous emissions, water supply, sewage and waste and remediation techniques for groundwater and contaminated soils.  
- Sized systems for the treatment of major pollutants vectors. Interprets rules, identifies goals, evaluates alternative techniques, proposes appropriate solutions and prioritize actions.  
- Definitions and porous medium soil and geological processes leading to soil.  
Transport and reaction of contaminants in saturated porous media: principles; transport processes: advection, molecular diffusion, hydrodynamic dispersion, sorption homogeneous and heterogeneous reactions; transport and reaction equations continuation equation, applications and examples.

Techniques thermal soil remediation: thermal desorption; incineration; vitrification; pyrolysis.

Techniques physicochemical soil remediation: soil flushing; solidification / stabilization; soil steam extraction (SVE); soil washing; electrokinetic.

Soil bioremediation techniques: phytoremediation; biodegradation; transformation with reduced toxicity; bioaccumulation bioaugmentation; inoculation; biological dehalogenation.

Physicochemical techniques groundwater remediation: containment; chemical dehalogenation; pumping and treatment of dissolved contaminants; bombeode hydrocarbons DNAPLs Treatment.

In situ techniques: natural attenuation; permeable reactive barriers; reactive areas, air sparging.

The aim of the course is to understand the behavior and transport mechanisms of non-aqueous phase organic liquids pollutants in the subsurface. Application to mathematical modeling, human health risk analysis and ecosystems.

<table>
<thead>
<tr>
<th>Study load</th>
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<tbody>
<tr>
<td><strong>Total learning time:</strong> 125h</td>
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<tr>
<td>Theory classes: 15h 12.00%</td>
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<tr>
<td>Practical classes: 10h 8.00%</td>
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<tr>
<td>Laboratory classes: 10h 8.00%</td>
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<td>Guided activities: 10h 8.00%</td>
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<tr>
<td>Self study: 80h 64.00%</td>
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## Content

### Introduction

<table>
<thead>
<tr>
<th>Learning time: 4h 48m</th>
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<tbody>
<tr>
<td>Theory classes: 2h</td>
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<tr>
<td>Self study: 2h 48m</td>
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</table>

**Description:**
Sources of contamination and types of contaminants
State waters and soils in Catalonia and Europe, description of the contamination problem

**Specific objectives:**
Understand the various sources and types of contamination of soil and groundwater
State waters and soils in Catalonia and Europe, conceptual models of contaminated sites

### Subsurface flow

<table>
<thead>
<tr>
<th>Learning time: 9h 36m</th>
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<tbody>
<tr>
<td>Theory classes: 4h</td>
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<tr>
<td>Self study: 5h 36m</td>
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**Description:**
Theory of subsurface flow
Continuity equation. Solutions in 1D and 2D
Basic concepts on well hydraulics

**Specific objectives:**

### Properties and characteristics of contaminants

<table>
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<tr>
<th>Learning time: 12h</th>
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<tr>
<td>Theory classes: 5h</td>
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<tr>
<td>Self study: 7h</td>
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</table>

**Description:**
Description of the parameters that control the infiltration capacity such as the viscosity, density and relative mobility.
Description of the parameters that control the distribution of mass between phases: solubility, vapor pressure, and distribution coefficient and Henry's constant
Description of the parameters that control movement: saturation, moisture content, interfacial tension, contact angle, capillary pressure, residual saturation, hydraulic conductivity, relative permeability

**Specific objectives:**
Knowing the parameters that control the infiltration capacity such as the viscosity, density and relative mobility.
Knowing the parameters that control the distribution of mass between phases: solubility, vapor pressure, distribution coefficient and Henry's constant
Knowing the parameters that control movement: saturation, moisture content, interfacial tension, contact angle, capillary pressure, residual saturation, hydraulic conductivity, relative permeability
### Contaminant transport

**Learning time:** 12h  
Theory classes: 5h  
Self study: 7h

**Description:**  
Description of the dissolution of non-aqueous liquids such as chlorinated solvents, gasoline, ...  
Description of transport processes in the saturated zone and presentation of basic equations of transport  
Description of transport processes in the vadose zone and the basic equations of transport of gases and vapors

**Specific objectives:**  
Learn to evaluate the time of dissolution and the dissolution of a cup of liquid non-aqueous  
Knowing the transport processes in the saturated zone  
Knowing the transport processes in the vadose zone and the basic equations of transport of gases and vapors

### Characterization of contaminated sites

**Learning time:** 7h 11m  
Theory classes: 3h  
Self study: 4h 11m

**Description:**  
Characterization of groundwater  
Characterization of soils  
Characterization of gases  
Characterization of NAPLs  
Description of how to interpret the results of analysis of water, soil and gases in the subsurface

**Specific objectives:**  
Learn the characterization of groundwater, soil, gas and NAPLs in contaminated sites  
Learn how to interpret the results of analysis of water, soil and gases in the subsurface

### Assessment of water contamination and soil

**Learning time:** 7h 11m  
Theory classes: 3h  
Self study: 4h 11m

**Description:**  
Presentation of the legislative framework for contaminated soil and water protection of the environment and human health  
Analysis risk to the environment and human health risk, toxicity and dose

**Specific objectives:**  
Learn the legislative framework for contaminated soil and water protection of the environment and human health  
Learn how to estimate the risk to the environment and human health problems associated with contamination of soil and groundwater
### Remediation engineering

**Description:**
Description of tècniques decontamination of groundwater
Description of the decontamination of polluted soils

**Specific objectives:**
Learn different techniques of decontamination of groundwater. Design and evaluation.
Learn techniques for decontamination of polluted soils. Design, implementation and evaluation.

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>9h 36m</th>
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<tbody>
<tr>
<td>Theory classes:</td>
<td>4h</td>
</tr>
<tr>
<td>Self study:</td>
<td>5h 36m</td>
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### Problem

**Description:**
Solving exercises in the classroom

**Specific objectives:**
Learn to evaluate, calculate, and project design.

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<thead>
<tr>
<th>Learning time:</th>
<th>19h 12m</th>
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<tbody>
<tr>
<td>Practical classes:</td>
<td>8h</td>
</tr>
<tr>
<td>Self study:</td>
<td>11h 12m</td>
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### Models of contaminated soils and aquifers

**Description:**
Presentation of models for risk analysis problems in contaminated soils and aquifers

**Specific objectives:**
Learn tools to assess the risk associated with a pollution problem

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>7h 11m</th>
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<tbody>
<tr>
<td>Laboratory classes:</td>
<td>3h</td>
</tr>
<tr>
<td>Self study:</td>
<td>4h 11m</td>
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### Guided activities

<table>
<thead>
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<th>Learning time:</th>
<th>4h 48m</th>
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<tbody>
<tr>
<td>Laboratory classes:</td>
<td>2h</td>
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<tr>
<td>Self study:</td>
<td>2h 48m</td>
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The rating will be obtained from continuous assessment of qualifications. Continuous assessment consists of doing various activities, both individual and group character and additive training, conducted during the year (in the classroom and outside of it). The rating is the average of the activities of this type, obtained through exercises (PR), a directed work (TD) and an examination (EX). The final mark is estimated as: $0.3 \times 0.4 \times PR \times 0.3 \times TD \times EX$

**Regulations for carrying out activities**

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

**Bibliography**