



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## SYLLABUS DEL CORSO

### Inquinamento e Bonifica delle Acque Sotterranee

2324-2-F7501Q086

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#### Aims

To know the main categories of groundwater contaminants and their possible sources;  
To distinguish between anthropogenic and natural pollution;  
To know the main chemical processes that contaminants create in groundwater;  
To know the chemical and physical characteristics of contaminants that influence their behavior in groundwater;  
To understand the concept of low solubility and separated fluid phase (NAPL) in relation to groundwater contamination;  
To be able to solve problems related to transport of contaminants subject to advection, dispersion, retardation and degradation phenomena;  
To know the main investigations to be carried out to acquire hydrogeological and hydrochemical knowledge aimed at a contamination case;  
To be able to develop a conceptual model of the problem based on the available data;  
To know the main techniques of groundwater remediation.

#### Contents

Study of contaminants and their propagation in groundwater;  
Methods of investigation for polluted area definition and site characterization;  
Methods for groundwater remediation;  
Guidelines for remediation monitoring.

#### Detailed program

Anthropogenic pollution and natural contamination;

Types of anthropogenic pollutants and pollution sources: characteristics, frequency, and distribution;  
Chemical and physical characteristics of contaminants;  
oxidation-reduction reactions in groundwater  
Transport mechanisms: advection, dispersion, adsorption and retardation, degradation;  
Principle of mass conservation and transport equation;  
Application of an analytical transport solution in the case of continuous source;  
Basic concepts of capillarity and wettability, permeability and relative permeability;  
Movement of non-soluble fluids NAPL, light and heavy (LNAPL and DNAPL);  
Hydrogeological and hydrochemical investigations and site characterization for a conceptual model building;  
Legislation on remediation with mention of risk analysis;  
Remediation modality (insitu, onsite, offsite) and criteria for selecting a remediation method;  
Main remediation techniques, with respect to: the principle of operation, physicochemical factors of influence, system feasibility, time of operation prediction, monitoring mode and timing, data interpretation, and achievement of remediation objectives;  
Technologies covered: Hydraulic Barrier, Soil Vapour Extraction, Air Sparging, Permeable Reactive Barrier, techniques for removal of separated phases (LNAPL, DNAPL) nodes to other remediation techniques.

## **Prerequisites**

Basic knowledge of hydrogeology.

## **Teaching form**

Lectures, 4 cfu.  
Tutorials, 2 cfu.

## **Textbook and teaching resource**

Materials used during lectures (slides, exercises, diagrams, material and spreadsheets of exercises) posted at:  
<https://elearning.unimib.it/course/view.php?id=51569>

Recommended texts (viewable from the lecturer):  
Francani V., 2014. Hydrogeology. C.E.A. Ambrosian Publishing House;  
Di Moffetta, Sethi, 2012. Aquifer engineering. Springer;  
Clark I., 2015. Groundwater Geochemistry and Isotopes. CRC Press

## **Semester**

First Semester.

## Assessment method

A final examination is scheduled in written mode with mandatory oral.

The written examination is aimed at assessing the acquisition of basic knowledge related to contaminants and to their transport in groundwater. The examination, lasting 3.5 hours, consists of:

- no.2 open-ended questions (demonstrate the ability to analyze, understand and describe a contamination phenomenon);
- no.3 closed-ended tests (demonstrate knowledge of basic concepts);
- no.1 problem (demonstrate the ability to solve questions related to a single case of contamination in a rational way).

The oral examination is aimed at assessing the acquired knowledge related to investigation and remediation methods and their application. The examination, lasting about 30 minutes, consists of:

- discussion of the written paper;
- interview on topics covered in class related to the remediation of contaminated sites (characterization, legislation, remediation techniques);

The evaluation of the written paper will award a maximum total score of 30/30 (7/30 questions, 3/30 tests, 20/30 problem).

The evaluation of the oral test is averaged with that of the written test to award the final grade

## Office hours

By appointment with the lecturer

## Sustainable Development Goals

CLEAN WATER AND SANITATION | RESPONSIBLE CONSUMPTION AND PRODUCTION

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