COURSE DESCRIPTION
GEOCHEMICAL SITE CHARACTERIZATION AND RISK ANALYSIS

SSD: GEOCHIMICA E VULCANOLOGIA (GEO/08)

DEGREE PROGRAMME: GEOSCIENZE PER L'AMBIENTE, LE RISORSE E I RISCHI NATURALI (DH0)
ACADEMIC YEAR 2026/2027

COURSE DESCRIPTION

TEACHER: ALBANESE STEFANO
PHONE: 081-2535059
EMAIL: stefano.albanese@unina.it

GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: NOT APPLICABLE
MODULE: NOT APPLICABLE
TEACHING LANGUAGE: ITALIANO
CHANNEL:
YEAR OF THE DEGREE PROGRAMME: II
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER I
CFU: 6

REQUIRED PRELIMINARY COURSES

None

PREREQUISITES

None

LEARNING GOALS

The course aims to provide students with basic knowledge of the main issues related to processes and sources of environmental contamination in different compartments (soil, water, and air) and on the assessment of risks to human health. Particular attention is devoted to understanding the processes of contaminant mobilization, with a focus on organic pollutants in groundwater. Alongside theoretical aspects, the course develops skills necessary to design site-specific characterization plans, conduct environmental sampling activities (including soil gases), and apply deterministic and stochastic methodologies for environmental risk assessment.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should demonstrate knowledge and understanding of the main processes and sources of environmental contamination at the site scale, with particular reference to soil, water, and air. They should be able to describe and illustrate the mechanisms of mobilization of organic and inorganic contaminants in environmental matrices, recognizing their implications for groundwater quality and human health.

The course provides the knowledge needed to distinguish between different types of contaminants, outline site-specific characterization methods, and identify the most appropriate sampling procedures, including soil gases. Students should also understand the theoretical and methodological principles underlying environmental risk assessment, in both deterministic and stochastic approaches, recognizing the relationships between field data, analytical results, and the definition of remediation targets.

Applying knowledge and understanding

Students should demonstrate the ability to concretely apply acquired knowledge to analyze and solve problems related to site-specific environmental contamination. They should be able to organize and implement a characterization plan, prepare and manage sampling activities in different environmental media (including soil gases), and correctly use the collected data to build and validate conceptual site models.

The course provides methodological and operational tools to apply environmental risk analysis procedures (deterministic and stochastic), transferring theoretical results to real-world cases. Students should also be able to analyze experimental data in the laboratory, verify the consistency of information, and use these results to establish remediation targets.

Through practical exercises and fieldwork, students will connect theoretical concepts to operational practice, demonstrating the ability to autonomously manage investigation, data processing, and evaluation phases in the context of site characterization and remediation.

COURSE CONTENT/SYLLABUS

1. Introduction and current status of contaminated sites (0.25 CFU = 0.25 LF)

•International definitions of a contaminated site (EPA, UK, Germany, Austria, Switzerland).
•Types of sites: Superfund, brownfields, RCRA, USTs, military sites.
•Current situation in Europe and Italy: census, statistics and ISPRA case studies.
•Main sectors and contaminants at European level (mineral oils, metals, hydrocarbons, solvents).

2. National and European regulatory framework (0.25 CFU = 0.25 LF)

•Directive 2004/35/EC on environmental liability.
•Legislative Decree 152/2006 – Consolidated Environmental Act:
•Part IV, Title V ‘Remediation of contaminated sites’.
•Definitions: CSC (Contamination Threshold Concentrations), CSR (Risk Threshold Concentrations).

•Operational and administrative procedures, characterisation plans, risk analysis.
•The ‘polluter pays’ principle.
•Distinction between contaminated, potentially contaminated and uncontaminated sites

3. Main contaminants at contaminated sites (0.5 CFU = 0.5 LF)
•Potentially Toxic Substances (PTEs): natural and anthropogenic origins, mobility, health effects.
•Mineral oils and aromatic hydrocarbons (BTEX, PAHs).
•Persistent organic compounds: pesticides, PCBs, dioxins, furans.
•Cyanides, phenols, chlorinated solvents.
•Processes of bioaccumulation, bioconcentration and biomagnification.
•Toxicological effects: neurotoxicity, carcinogenicity, damage to target organs.

4. Migration and fate of contaminants (1 CFU)
•Physical and chemical properties of soils: porosity, permeability, capillary zone.
•Unsaturated zone and saturated zone: transport in the various compartments.
•Transport mechanisms: advection, hydrodynamic dispersion, molecular diffusion.
•Attenuation processes: volatilisation, adsorption, chemical and biological degradation.
•Contamination plumes and retardation factors.
•Conceptual models for predicting the fate of contaminants.

5. Characterisation plan and investigation strategies (0.5 CFU = 0.5 LF)
•Definition and objectives of the characterisation plan.
•Collection of historical and environmental data, preliminary investigations.
•Site delineation and intended end use.
•Geological and hydrogeological context.
•Preliminary conceptual and investigative model.
•Sampling techniques and environmental media: soil, subsoil, groundwater, soil vapours.
•Laboratory analyses and historical data to support characterisation.

6. Site-specific risk analysis (2.5 CFU = 0.5 LF + 2 LAB)
•Definition of risk and methodological approaches (deterministic and probabilistic).
•Concepts of exposure, toxicity and dose-response.
•Threshold and non-threshold contaminants (RfD, TDI, Slope Factor).
•Conceptual site model (CSM) and exposure scenarios.
•RBCA (Risk-Based Corrective Action) procedures:
•Tier 1: conservative screening (RBSL).
•Tier 2: site-specific analysis using SSTL.
•Tier 3: numerical modelling and probabilistic approach (Monte Carlo).
•Operational applications: calculation of remediation targets, sensitivity analysis.
•Modelling of contaminant migration in groundwater
•Case studies and practical applications.

7. Educational field trip (1 CFU = 1 AC)

Key
LF = Lectures
LAB = Practical sessions
AC = Fieldwork

READINGS/BIBLIOGRAPHY

Reccomended texts

1. AA.VV., 2006. Manuale per le indagini ambientali nei siti contaminati.APAT. Manuali e linee guida 43/2006. ISBN: 88-448-0234-1 (Download link: http://www.isprambiente.gov.it/contentfiles/00003400/3458-manuale-2006-43.pdf/)
2. AA.VV., 2008. Criteri metodologici per l'applicazione dell'analisi assoluta di rischio ai siti contaminati (revisione 2, marzo 2008) (Download link:http://www.isprambiente.gov.it/files/temi/siti-contaminati-02marzo08.pdf)
3. AA.VV., 2008. Criteri metodologici per l'applicazione dell'analisi assoluta di rischio ai siti contaminati - Appendici (revisione 2, marzo 2008) (Download link: https://www.isprambiente.gov.it/files/temi/siti-contam-marzo2008-appendici-rev2.zip)
4. AA.VV., 2008. Documento di riferimento per la determinazione e la validazione dei parametri sito-specifici utilizzati nell'applicazione dell'analisi di rischio ai sensi del DLgs 152/06 (Giugno 2008). (Download link: https://www.isprambiente.gov.it/files/temi/documentopervalidazioneparametrisito-specifici.pdf)
5. AA.VV., 2019. Bonifica dei siti inquinati. Geologia dell'Ambiente, Supplemento al n. 2/2019. SIGEA. (Download link: https://www.sigeaweb.it/documenti/gda-supplemento-2-2019.pdf)
6. AA.VV. Le bonifiche ambientali nell'ambito della transizione ecologica. Monografie di Geologia Ambientale, 01/2022. SIGEA. (Download link: https://www.sigeaweb.it/documenti/monografie/Monografie-GA-01-2022.pdf)

Additional material

Slides provided by the instructor at the end of each lecture (see syllabus). Available to enrolled students on the instructor's website.

TEACHING METHODS OF THE COURSE (OR MODULE)

a) Lectures: 3 ECTS
b) Practical exercises (software: Excel, JASP, QGIS, Risk-net, ProUCL): 2 ECTS
c) Fieldwork: 1 ECTS

EXAMINATION/EVALUATION CRITERIA

a) Exam type

☐ Written
☑ Oral

- [x] Project discussion
- [ ] Other

In case of a written exam, questions refer to

- [ ] Multiple choice answers
- [ ] Open answers
- [ ] Numerical exercises

b) Evaluation pattern

The ORAL EXAM will take place after the course lectures end.
The ORAL EXAM will consist of questions on the course topics and a discussion of the results of the PROJECT WORK; for the PROJECT WORK, students will be required to complete an environmental health risk analysis based on data provided by the instructor.