**University of Zagreb Faculty of Agriculture**
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# Biogeochemistry of metals in soil (152100)

## Course coordinator

**Prof. Gabrijel Ondrašek, PhD**

## Course description

The aim of the course "Biogeochemistry of soil trace metals" is to give general and specialistic knowledge from the environmental geochemistry, and to enable students to connect physical, chemical and biological factors which affect metal circling in terrestrial ecosystem, processes which intermediate in biogeochemical circling, and finally, status and health of the organisms in a certain ecosystem. In the focus of the course is soil, soil quality concept and the importance of natural and anthropogenic soils chemistry in the environmental protection.

ECTS: **3.00**

E-learning: **L1**

**Teaching hours: 30**
Lectures: 18
Laboratory exercises: 8
Seminar: 4

**Lecturer**

- Prof. Gabrijel Ondrašek, PhD

**Associate teacher for exercises**

- Jelena Horvatinec, PhD
- Assoc. Prof. Monika Zovko, PhD

**Associate teacher for seminars**

- Prof. Gabrijel Ondrašek, PhD

**Grading**

Sufficient (2): 60-69 %
Good (3): 70-79 %
Very good (4): 80-89 %
Excellent (5): 90-100%

**Conditions for obtaining signature**

Attending lectures and all laboratory exercises, Completed seminar

**Description**

Written exam

## Type of course

- Graduate studies / MS Courses taught in English (Elective course, 2 semester, 1 year)

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# General competencies

Module Biogeochemistry of soil metals enables the student with the fundamental knowledge about the physical, chemical and biological factors, as well as their interactions, which affect metal circling in terrestrial ecosystems. Students will be able to define the most important processes in specific metal characterization and bioavailability, as well as apply knowledge in the field of spatial analysis, geostatistics and mapping, all as a part of environmental protection concept.

# Types of instruction

- Lectures
  Classroom lectures throughout semester
- Laboratory practice/exercises
  Laboratory exercises conducted in groups (max 10 students): as part of the laboratory exercises analyses are carried out with different instrumental chemical methods UV/VIS, AAS, SFA, ICP-OES
- Seminars
  Related to the effects of the physical, chemical and biological processes, as well as their interactions, on the metal circling in the terrestrial ecosystem.

# Methods of grading

| Evaluation elements | Maximum points or Share in evaluation | Grade rating scale | Grade | Direct teaching hours | Total number of average student workload | ECTS |
|---|---|---|---|---|---|---|
| Laboratory exercises | 0,5 | 0-4,75<br>5-5,75<br>6-6,75<br>7-7,75<br>8 | Insufficient (1)<br>Sufficient (2)<br>Good (3)<br>Very good (4)<br>Excellent (5) | 8 | 8 | 0,5 |
| Total | 0,5 | 0-8 | 1-5 | 8 | 8 | 0,5 |

| Evaluation elements | Maximum points or Share in evaluation | Grade rating scale | Grade | Direct teaching hours | Total number of average student workload | ECTS |
|---|---|---|---|---|---|---|
| Written exam | 2 | 0-5,75<br>6-6,75<br>7-7,75<br>8-8,75<br>9-10 | Insufficient (1)<br>Sufficient (2)<br>Good (3)<br>Very good (4)<br>Excellent (5) | 18 | 18 | 2 |
| Total | 2 | 0-10 | 1-5 | 18 | 18 | 2 |

| Evaluation elements | Maximum points or Share in evaluation | Grade rating scale | Grade | Direct teaching hours | Total number of average student workload | ECTS |
|---|---|---|---|---|---|---|
| Seminar | 0,5 | 0-1,75<br>2-2,75<br>3-3,75<br>4-4,75<br>5 | Insufficient (1)<br>Sufficient (2)<br>Good (3)<br>Very good (4)<br>Excellent (5) | 4 | 4 | 0,5 |

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| Evaluation elements | Maximum points or Share in evaluation | Grade rating scale | Grade | Direct teaching hours | Total number of average student workload | ECTS |
|---|---|---|---|---|---|---|
| Total | 0,5 | 0-5 | 1-5 | 4 | 4 | 0,5 |

| Evaluation elements | Description | Deadline | Recoupment |
|---|---|---|---|
| Laboratory exercises | Attending laboratory exercises | End of semester | Subsequent attending of laboratory exercises, seminar |
| Written exam | Written exam | Written exam dates | - |
| Seminar | Preparation and presentation of seminar | End of semester | Subsequent preparation and presentation of seminar |

## Weekly class schedule

1. Terrestrial ecosystem sustainability principles and distortion of its sustainability L - Structure and functioning of terrestrial ecosystems (the circulation of matter and flow of energy, relations and interactions between organisms in the ecosystem).
2. Sources and origin of potentially toxic metals in soil L - Soil quality concept, the importance of soil chemistry for natural and anthropogenic soils in environmental protection, natural and anthropogenic factors which may lead to accumulation of metals in soil.
3. Biogeochemical metal circling in natural and perturbed terrestrial ecosystems L - Natural geochemical concentrations, anthropogenic emission, the immobilization and dispersion of metals in soil and other environmental media (aquatic ecosystems, organisms, atmosphere, and geochemical barriers and metal mobility), interactions of soil, microorganisms and plants in metal uptake from soil solution.
4. Metal mobility in a terrestrial environment L - Biogeochemical circling of metals and metalloids: mobilization and remobilization depending on redox conditions and sequestering.
5. Metal mobility in a terrestrial environment L - Biogeochemical circling of metals and metalloids: mobilization and remobilization depending on redox conditions and sequestering.
6. Calculation of chemical equilibrium in a soil solution S - Appliance of principles of metal ions chemical equilibrium in a soil solution used in clarifying of mechanisms which control potentially toxic metals mobility. Calculation of chemical equilibrium with Visual MINTEQ model (metal speciation, solution equilibrium, sorption, etc.). The model combines sorption and complexation reactions. Processing output data in Excel.
7. Approaches for characterization and assessment of metal phytoavailability E - Mechanistic approach focused on understanding of main biogeochemical metal dynamics initiators in the soil-root interface (rhizosphere) , risk assessment approach, composite test for assessment of plant available metal in soil.
8. Approaches for characterization and assessment of metal phytoavailability E - Mechanistic approach focused on understanding of main biogeochemical metal dynamics initiators in the soil-root interface (rhizosphere) , risk assessment approach, composite test for assessment of plant available metal in soil.
9. Spatial analysis, geostatistics and mapping; Methods for contamination origin identification and contaminated soils monitoring L - Introduction to spatial analysis: nature of metal spatial variability in soils (spatial variability of soil characteristics implies systematic and random components; systematic variability is a gradual change (trend) caused by

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pedogenetic processes (topography, lithology, climate, biological activity, soil age, physical–chemical properties); spatial variability assessment (mechanistic models based on physical laws and deterministic in predictions; statistical models which recognize uncertainty related to assessment); statistical aspects of spatial classification.

10. Spatial analysis, geostatistics and mapping; Methods for contamination origin identification and contaminated soils monitoring L - Introduction to spatial analysis: nature of metal spatial variability in soils (spatial variability of soil characteristics implies systematic and random components; systematic variability is a gradual change (trend) caused by pedogenetic processes (topography, lithology, climate, biological activity, soil age, physical–chemical properties); spatial variability assessment (mechanistic models based on physical laws and deterministic in predictions; statistical models which recognize uncertainty related to assessment); statistical aspects of spatial classification.
11. Geochemical methods in soil heavy metals and potentially toxic elements contamination assessment E - Case studies (data collecting, spatial variability assessment, soil element spatial distribution mapping – generating thematic charts, usage of software in statistics, geostatistics – ISATIS and mapping – GIS).
12. Geochemical methods in soil heavy metals and potentially toxic elements contamination assessment E - Case studies (data collecting, spatial variability assessment, soil element spatial distribution mapping – generating thematic charts, usage of software in statistics, geostatistics – ISATIS and mapping – GIS).
13. Connecting physical, chemical and biological factors which affect metal circling in terrestrial ecosystems S - Interpretation of the most important factors in biogeochemical process of particular metal circling.
14. Written exam S
15. Written exam S

## Obligatory literature

1. Kim H.T: (1994): Environmental soil science. Marcel Dekker, INC, New York InTech, p. 437-456.
2. Brady C.N., Weil R.R. (2002): The Nature and Properties of Soils, 13th Edition, Prentice Hall, New Jersey
3. Bohn H.L., McNeal B.L:, O´Connor G. (2001): Soil Chemistry, 3rd Edition, John Wiley & Sons, Inc.
4. Jury W.A., Horton R. (2004): Soil Physics, 6th Edition, John Wiley & Sons, Inc.
5. Zovko M., Romić M. 2011. Soil contamination by trace metals: Geochemical behaviour as an element of risk assessment (poglavlje u knjizi: Earth and Environmental Sciences). Ahmad Dar, Imran (ur.). Rijeka, InTech, p. 437-456.
6. Castrignano A. 2011. Introduction to spatial data processing. CRA - SCA, Bari, Italija

## Recommended literature

1. Environmental Chemistry of Soils, Murray B. McBride, Oxford University Press, 1994.