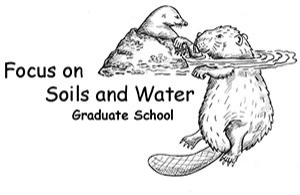
PNS0209 Course Syllabus

Soil systems: integrating chemical and biophysical interfaces in soils, 3 credits



Objectives

Soil is the most complex and heterogeneous system on earth in terms of its physical structure, chemical constitution and inherent biodiversity. In recent decades, methodological developments in the study of chemical and biophysical interfaces at the micro-scale have provided new opportunities to soil scientists to promote interdisciplinary research and integrate process understanding into a holistic soil system view. In this approach, soil is seen as a complex, adaptive and structured system in which macroscopic properties and processes depend on interactions at smaller spatial scales.

Indeed, our ability to describe small-scale soil interactions has been transformed by the use of modern technologies applied to intact soils, including the visualization, quantification and spatial analysis of soil components and functions (e.g. X-ray tomography, microscopy and microanalysis) together with integrated measurements of biological activity through enzyme activities or energy flows (e.g. thermodynamics). The exploration of these interactions in the minute soil universe has, in turn, profound implications for our understanding of soil functions at field, catchment and regional scales relevant to the sustainable use and protection of soils and water.

The aim of this course is to

(i) provide an introduction to soils as complex, adaptive structured systems;

(ii) give an overview of recent micro-analytical methods to explore interactions at soil chemical and biophysical interfaces, and their application to soil samples;

(iii) present how the knowledge gained of microscale processes can inform soil management, policy and decision making at larger scales;

(iv) discuss opportunities and challenges of these micro-analytical methods applied to soil as well as possible future innovative development and applications.

Learning outcomes

After completion of the course, the student should be able to:

- define the soil as an adaptive, complex, and structured system
- describe modern techniques for the visualization and quantification of chemical and biophysical interfaces in soil as well as their application to the study of soil functions and processes
- discuss some opportunities and challenges in using the micro-analytical methods presented in the course

Target group

This course is primarily intended for PhD students participating in the Focus on Soils & Water graduate school, but is also open to other PhD students working in related research areas. Researchers are also very welcome to participate in lectures and discussions, if places are available. There are no specific requirements concerning prior knowledge.

Content

The course consists of two parts:

1) Literature group meetings: selected research and review papers will be discussed as well as student oral or poster presentations (three meetings prior to, and one meeting after, the workshop).
2) A workshop (see below) will be held at Ultuna with participation of international leading scientists in this research area.

Literature

The course literature will consist of research and review papers selected by the invited lecturers

Number of ETCS-credits

In total 3 ECTS

Examination

- Read the literature provided and attend the literature group meetings
- Final literature group meeting: give an oral (10-15 minutes) or poster presentation on your own research assessing in what way(s) a soil system view is critical to your work
- Active participation in group meetings and workshop discussions

Workshop 18th – 22nd of August 2025

Program's skeleton

Monday 18/8	**DAY 1** Soil as *as complex, adaptive structured systems (Claire, Anke, Nick, Naoise)*
Tuesday 19/8	**DAY 2** *Soil interactions in the natural soil habitat: Technical advances (1) - biogeochemical interfaces (Marco, Jon-Petter, Grace, Sara, Seeta)*
Wednesday 20/8	**DAY 3** *Soil interactions in the natural soil habitat: Technical advances (2) and spatial analysis- biophysical interfaces (Steffen, Naoise, Claire, Mats)*
Thursday 21/8	**DAY 4** *Relevance of the soil systems approach for soil management, policy and decision making (Claire, Stefano, Sara, Nick, Seeta, Jon-Petter)*
Friday 22/8	**DAY 5** *Future Opportunities and challenges of micro-analytical methods of intact soils (All)*

Proposed Speakers and area of interest relevant for the course

- **SLU researchers, including professors**

Anke Herrmann
Microbial carbon use efficiency (DAY 1), thermodynamics/ microcalorimetry (DAY 2)
Nick Jarvis
Soil structure - SOM dynamics (DAY 1), Pesticide risk assessment (DAY 4)
Mats Larsbo
Soil structure and aoil functions, X-ray tomography (DAY 3)
Sara Hallin
Plant soil microbial feedbacks (DAY 2), Microbial ecology from molecular to field scale (DAY 4)
Jon-Petter Gustafsson
Colloids interfaces / organo-mineral interactions / XANES spectroscopy (DAY 2),
Contaminated soils / toxicity to soil microorganisms and plants (DAY 4)
Grace Pold
Soil microbial carbon use efficiency, CUE (DAY 2)
Seeta Sistla (August T Larsson researcher; California Polytechnic State University)
Energetic and enzymatic limitations in soils, stoichiometry (DAY 2, DAY 4)

- **External speakers**

Claire Chenu: AgroParisTech, France
Save soils to offer a holistic solution (DAY 1 and 4)
Visualization of soil biota and of soil aggregation / Modelling C in the microbial habitat (DAY 3)
Naoise Nunan: CNRS, France
Biogeography of microbial communities, spatial analysis (DAY 3)
Stefano Manzoni: Stockholm University, Sweden
Soil C and N mineralization: Theory and models across scales / Carbon use efficiency from organisms to ecosystems (DAY 4)
Marco Keiluweit: University of Lausanne, Switzerland
Microenvironments mapping in soils (planar optode imaging system; in situ microsensors) (DAY 2), Rhizosphere (DAY 3)
Steffen Schlüter: UFZ, Leipzig, Germany
Spatial substrate heterogeneity, X-ray tomography (DAY 2), From rhizosphere to detritusphere: soil structure formation driven by roots and soil biota (DAY 3)