Innovative Postgraduate Education in The Field of Environment Protection: Methods and Tools

Soil Spectroscopy

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BIO Presenter

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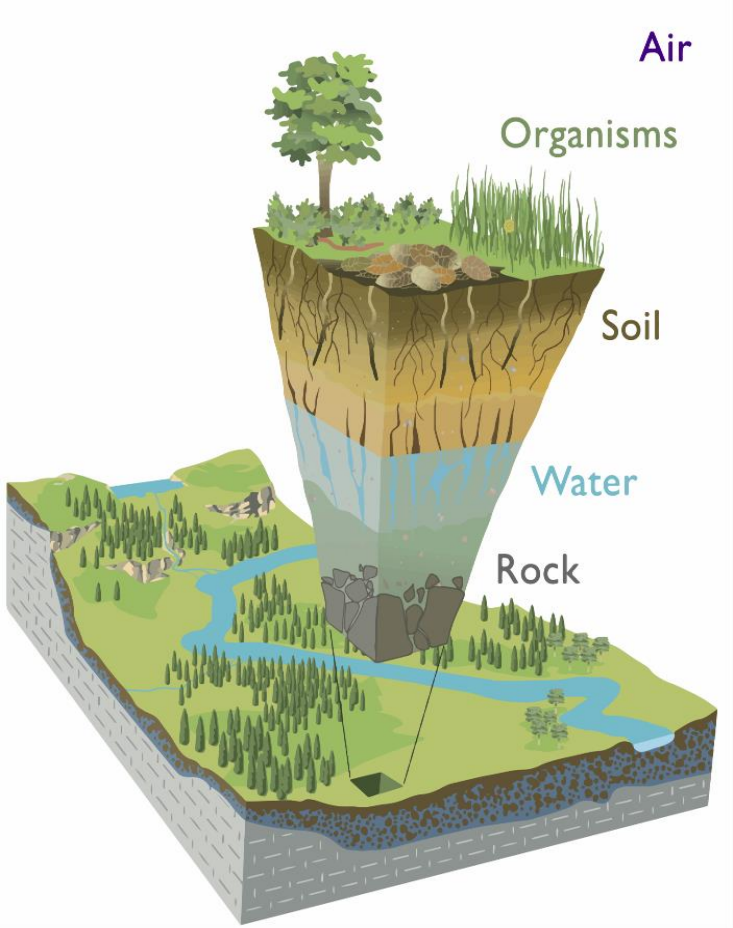
Modernized/New Developed Course

Soil Spectroscopy



MSc Curricula

Under modernization
- Environmental geochemistry
- Environmental monitoring and measurement devices
- Environmental toxicology

Newly developed
- Soil quality management

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Course Objectives

1. Get acquainted with fundamentals of vis-NIR and MIR

2. Understand how their interact with the materials, in particular with soil

3. Get knowledge on common lab procedures for vis-NIR and MIR soil analysis, with an emphasis on spectral acquisition, spectral reprocessing, model training and testing, partial least squares regression, and model performance assessment

4. Get knowledge on soil chemical, physical, and biological functions and how they can be studied with FTIR spectroscopy also taking into account environmental pollution

5. Work with vis-NIR and MIR soil spectral libraries across the regional, national, and global scales

4. Get skills on soil quality monitoring indicators and how to define them for soil quality monitoring

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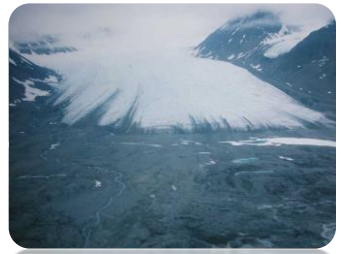
Course Prerequisites

- high level of knowledge within soil science, agronomy, or environmental engineering and management
- basic knowledge of soils, physics, and statistics



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Why FTIR spectroscopy for soil analysis

- possibilities of NIRS to innovative soil analysis

  - fast and accurate estimates of soil properties illustrating the potential alternative to current traditional wet chemistry analysis;
  - high quality and cheap soil data;
  - input to precision agriculture, soil health monitoring, soil management, and environmental protection tasks.

Properties estimated:

DIRECT & INDIRECT

- organic matter (or organic carbon)
- carbonate (or inorganic carbon)
- total nitrogen
- clay minerals
- iron content
- particle size fractions of clay, silt, and sand
- water content

- soil cations (e.g. Mg or Ca)
- pH
- CEC (Cation Exchange Capacity)
- salinity
- nutrient contents (e.g. total phosphorus and potassium)

!!! empirical and heavily “data-driven”

N.B. Multi-variate modeling and machine learning methods involving all wavebands are the mainstream approaches

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Course Program

Lectures: they would introduce the students to the topics.

Seminars: it would go deepen in some topics (i.e. environmental pollution detection, indicators, other applications of material FTIR spectroscopy on other matrices, applied remote sensing spectroscopy for environment).

Practical: the students would participate in group work based on hands-on laboratory and computer assignments. On the last day of the course the students would give presentations with the main findings from their assignments.

The course covers the following topics:

- Fundamentals of NIRS
- Calibration considerations
- Sample preparation
- Instrumentation: theory and hands-on experience
- Examples of the NIRS-based estimations of basic and functional soil properties using lab and in- field collected data
- Chemometrics: theory and computer exercises

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Course Outcomes

(according to the course curricula)

At the end of the course,

the students should be able:

- to describe the principals of NIR spectroscopy as well as to summarize its applications
- to prepare soil samples for FTIR analysis
- to understand soil spectra and their properties
- to critically evaluate the performance of the models
- to estimate some chemical parameters

the students should have:

- theoretical knowledge about the principals on developing calibration models
- basic skills to use software functions and methods for exploratory data analysis and spectral model generation for basic soil properties estimation

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Interdisciplinary Connections With Other Courses and lab facilities in Georgia & Armenia

Complementary to SEM and HPLC analysis

SOIL, BIOMASSES CHARACTERIZATION, MATERIAL STUDIES

ENVIRONMENTAL STUDIES, INCLUDED FOOD CONTAMINATION ANALYSIS AND APPLIED REMOTE/PROSSIMAL SENSING FOR ENVIRONMENT

ECOLOGICAL STUDIES

- Organism adaptation and response mechanisms to abiotic and biotic stresses even in extreme environments

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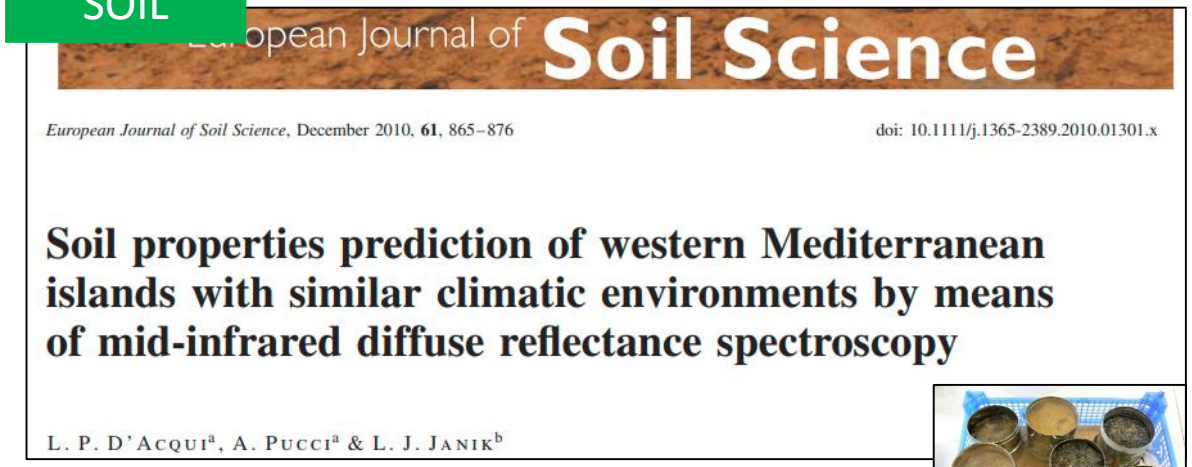
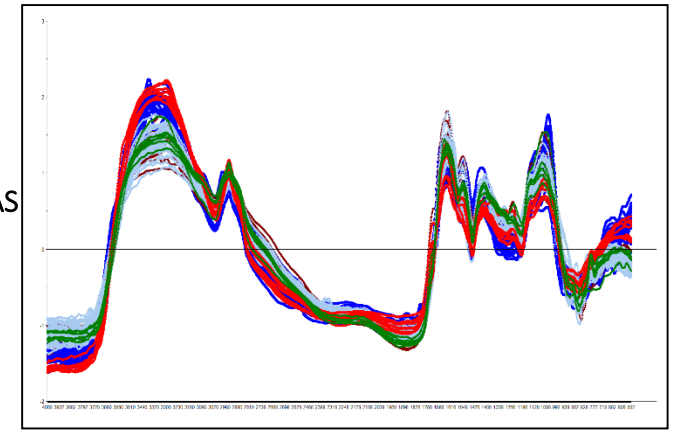
FTIR spectrometry analysis

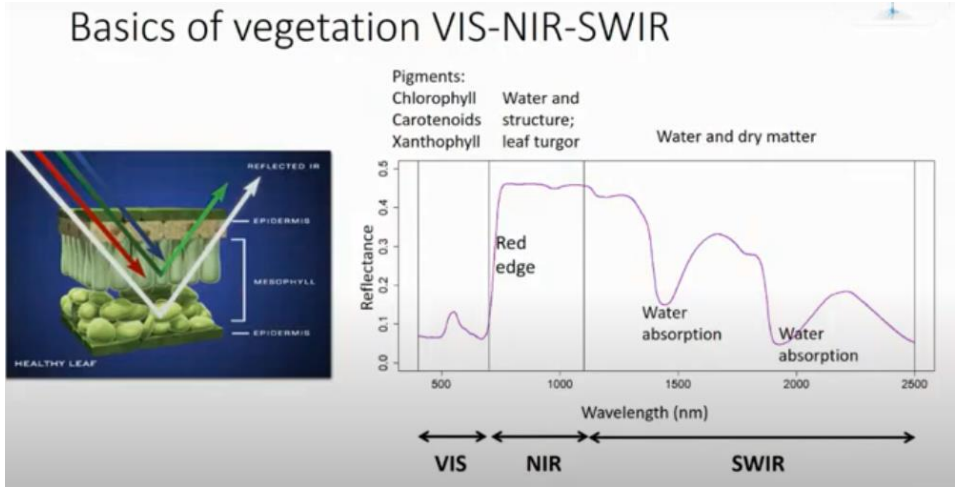
SOIL



MICRORGANISMS

Infrared characterization of *Nostoc* cf. *commune* laminar macrocolonies by using FTIR-PAS (photoacoustic)





PLANTS

Leaf-level hyperspectral reflectance to rapidly estimate plant chemical traits

Literature on leaf VIS-NIR-SWIR analysis

- Leaf physiological parameters
  - Gas exchange (stomatal conductance)
  - Pigments (Chlorophyll, carotenoids, anthocyanin)
  - Photosynthesis (V_{cmax}, J_{cmax}, A_{max})
  - Water content, Dark respiration
- Leaf macronutrient contents
  - Nitrogen, phosphorus, C:N ratio
- Leaf structural parameters
  - Leaf mass per area
- Metabolites
  - Carbohydrates (Sucrose, glucose, free amino acids)
  - Phenolic compounds

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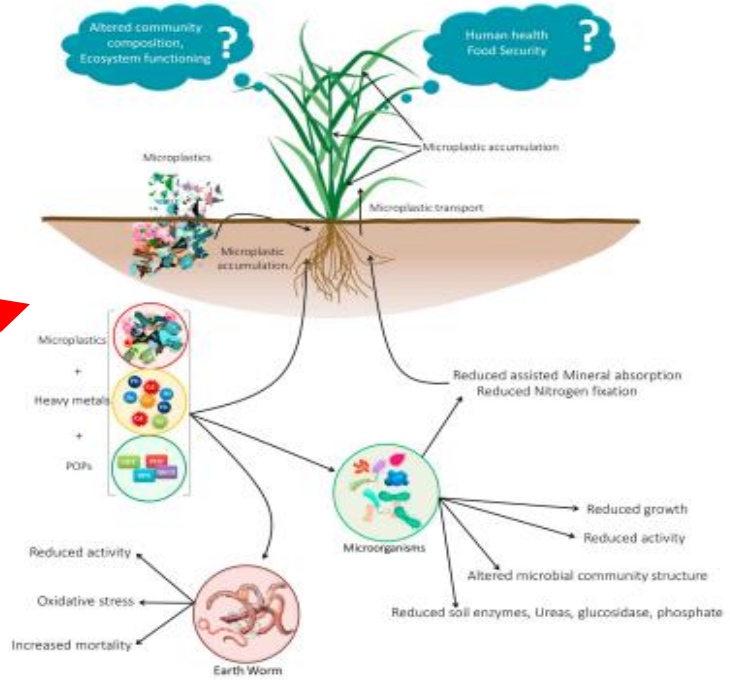
Microplastics

Generation and dispersion of microplastics in terrestrial environments (adapted and modified from Karbalaei et al., 2018).



MPs in the soil affect plant growth directly or indirectly by impacting the growth of soil-dwelling organisms.

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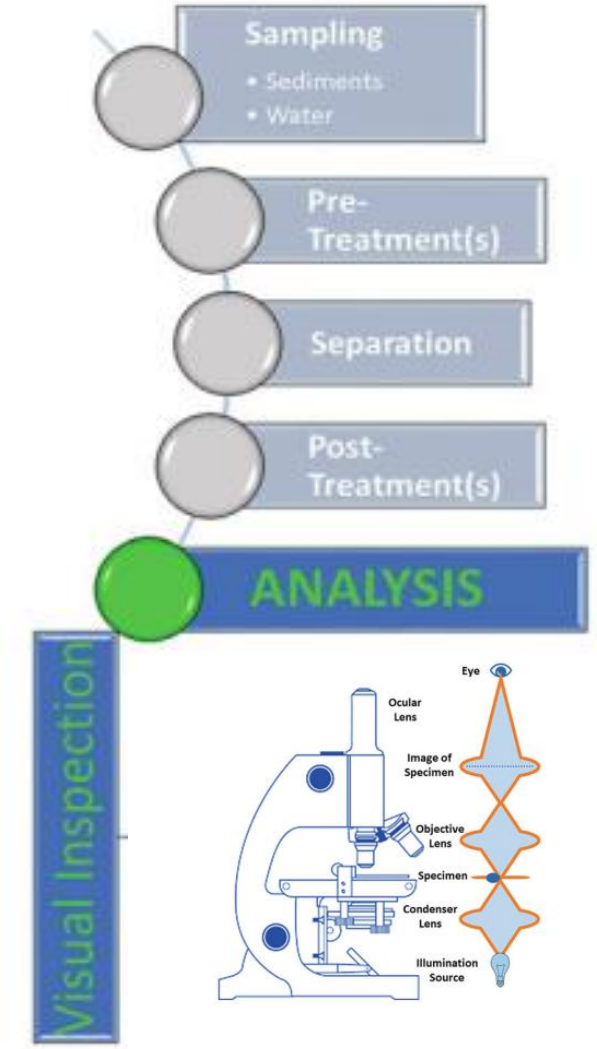
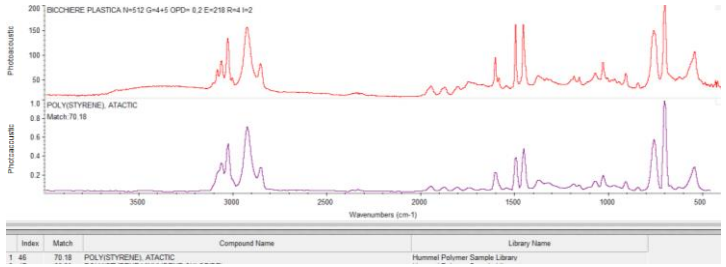
Pipeline for microplastic analysis with FTIR spectroscopy





Important reference

FAO. 2022. A primer on soil analysis using visible and near-infrared (vis-NIR) and mid-infrared (MIR) spectroscopy.Rome, FAO. https://doi.org/10.4060/cb9005en

THANK YOU !

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