Detection of contaminants in solid matrices and plants

Piet Seuntjens, Alain De Vocht, Christy Huybrechts, Christine Van Hoof, Luc Bertels, Ils Reusen
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Outline

- Problem and objectives
- Methods
- Results
  - Zinc ash roads
  - Vegetation
- Conclusions
Problem

- Heavy metal contamination in the “Kempen”
Problem

- Heavy metal contamination in the “Kempen”
- Zinc ash roads
  - Diffuse geographical occurrence
  - High metal concentrations
    - $6.606 \text{ Pb}, 40.750 \text{ Zn}, 1.613 \text{ Cu (mg/kg)}$
ZINKASSENWEGEN IN PROVINCIE ANTWERPEN EN LIMBURG.
Problem

- Heavy metal contamination in the “Kempen”
- Zinc ash roads
  - Diffuse geographical occurrence
  - High metal concentrations
    - 6.606 Pb, 40.750 Zn, 1.613 Cu (mg/kg)
- Vegetation
  - Toxic plant concentrations
  - Molecular, biochemical and physiological responses to metal stress occur
  - Large polluted area
Maatheide - Lommel
Vegetative stress
Objectives

- Pilot survey to test the feasibility of (hyper)spectral sensors to:
  - Gain additional information on the presence of zinc ash roads
  - Detect metal stress in plants
Methods

- Flight campaign
  - Seven flight-lines Dornier 228
  - CASI2 and SASI sensors
- Ground measurements
  - Ash roads
  - Vegetation
- CASI and SASI image processing
Flight campaign
Ground measurements

- Zinc ash roads
  - Metal concentration in top layer (X-ray fluorescence)
  - Reflectance measurements on 4 ash roads Fieldspec Pro PR (field and lab - dry/wet)
Reflectance of ash roads
Ground measurements

- Vegetation
  - Birch (*Betula pendula*)
    - Five plots, 3-4 individual trees
Birch plots
Ground measurements

Vegetation

- Birch (*Betula pendula*)
  - Five plots, 3-4 individual trees
  - Gas exchange (LCA4 gas analyser with PLC), chlorophyll fluorescence (FIS) and reflectance (Li-Cor 1800 and FieldSpec Pro FR)
  - Metal concentrations (AAS)
- Zinc concentration in 2-y needles of Pine (*Pinus sylvestris*) (AAS)
CASI-SASI image processing

- Zinc ash roads
  - Corrected SASI-data
  - Filtered using semi-interactive smoothing algorithm (Vito)
  - Library of reference spectra of pure zinc and asphalt roads
  - Library mixed with neighboring vegetation pixels: temporary library set
  - Spectral Angle Mapper
  - Low reflectance in SWIR
CASI-SASI image processing

- Vegetation
  - Corrected CASI2 and SASI
  - Smoothing algorithm
  - Selection of regions of interest for pine
  - Spectral Angle Mapper: pine mask
  - Edge Green First derivative Normalized difference (EGFN) calculated for each pixel
Results

- Zinc ash roads
  - Three bands: R (power), G (fraction) and B (spectral angle)
  - Ash roads: green
Zinc ash roads
Zinc ash roads
Vegetation

- Metal concentration in Birch leaves
- Gas exchange (gs: stomatal conductance)
- Fluorescence (M: max. Fluor. Int.)
- Reflectance (EGFN)
Gas exchange

Box & Whisker plots for different gas exchange measurements:
- GS
- CD
- CU
- PB

The plots show the distribution of values with mean, standard deviation (SD), standard error (SE), and confidence intervals.
Fluorescence

<table>
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<th>M</th>
<th>Phi</th>
<th>Rfd</th>
<th>Vi</th>
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<tr>
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Fluorescence

CDMGKGS vs. MEAN
MEAN = 97.104 + 10.988 * CDMGKGS
Correlation: r = .84542

CUMGKGS vs. MEAN
MEAN = 103.11 + 3.8788 * CUMGKGS
Correlation: r = .57454

ZNMGKGS vs. MEAN
MEAN = 123.03 + 0.00870 * ZNMGKGS
Correlation: r = .16397

PBMGKGS vs. MEAN
MEAN = 114.97 + 1.5840 * PBMGKGS
Correlation: r = .55449
Reflectance

**CD vs. EFGN**

EFGN = 0.62331 - 0.01076 * CD

Correlation: r = -0.2685

**ZN vs. EFGN**

EFGN = 0.63075 - 0.00006 * ZN

Correlation: r = -0.2094

**PB vs. EFGN**

EFGN = 0.62682 - 0.00366 * PB

Correlation: r = -0.3810

**CU vs. EFGN**

EFGN = 0.64967 - 0.00766 * CU

Correlation: r = -0.3417
Different sensitivity of stress indicators

\[
\text{Correlation: } r = -0.5793
\]

\[
\text{EGFN} = 0.69660 - 0.00086 \times M
\]
EGFN vegetation stress map
Conclusions

Zinc ash roads

- Distinct zinc ash roads are classified as such
- Misclassification of some roads in respect to the metal concentrations
- No correlation between zinc concentrations in samples and reflectance spectra
Vegetation

- Stress indicators have different sensitivity and robustness
- Relation between aerial reflectance and internal metal concentrations remain unclear
- Further analysis and tests will be needed to verify the aerial stress image
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