Landscape-Specific Correlation between Atmospheric Depositions and their Concentrations in Mosses 2005 across Europe?

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Results: **Correlations Cd & Pb (Moss) – Cd & Pb (Dep) within Countries**
Background and Aim

Correlations of HM and N concentrations in mosses and atmospheric depositions proved for

• **Europe** (Schröder et al. 2008, 2010)
  
  Used for mapping depositions 5 km by 5 km (Schröder et al. 2011, 2012)

• **European countries** (Harmens et al. 2012)

**Landscape**-specific correlations of HM and N in atmospheric **depositions** and **mosses** 2005?
Data: Ecological Land Classification Europe (ELCE)

Sources:
Vegetation: BfN 2003
Digital elevation model: NOAA/NGDC 1999
Soil texture: FAO/UNESCO 1996
Climate: CRU 2002
Country borders: ESRI 2003
### Data: 26 Potential Predictors (Local, Regional)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Resolution</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moss species</td>
<td>site-specific</td>
<td></td>
</tr>
<tr>
<td>Altitude</td>
<td>site-specific</td>
<td></td>
</tr>
<tr>
<td>Digestion method</td>
<td>site-specific</td>
<td></td>
</tr>
<tr>
<td>Analytical method</td>
<td>country-specific</td>
<td></td>
</tr>
<tr>
<td>Sea distance</td>
<td>site-specific</td>
<td></td>
</tr>
<tr>
<td>Precipitation (1961-1990)</td>
<td>12.5 km x 12.5 km</td>
<td>CRU(^1)</td>
</tr>
<tr>
<td>Population density</td>
<td>100 m x 100 m</td>
<td>EEA(^2)</td>
</tr>
<tr>
<td>Agricultural land uses (1, 5, 10, 25 km radius)</td>
<td>1 km x 1 km</td>
<td>EEA(^2)</td>
</tr>
<tr>
<td>Forest areas (1, 5, 10, 25 km radius)</td>
<td>1 km x 1 km</td>
<td>EEA(^2)</td>
</tr>
<tr>
<td>Urban areas (1, 5, 10, 25, 50 km radius)</td>
<td>1 km x 1 km</td>
<td>EEA(^2)</td>
</tr>
<tr>
<td>Urban areas (75, 100 km radius)</td>
<td>2 km x 2 km</td>
<td>EEA(^2)</td>
</tr>
<tr>
<td>Anthropogenic emissions (Cd, Pb, N)</td>
<td>50 km x 50 km</td>
<td>MSC-WEST(^3)/East(^4)</td>
</tr>
<tr>
<td>Natural emissions (Cd, Hg, Pb, N)</td>
<td>50 km x 50 km</td>
<td>MSC-WEST(^3)/East(^4)</td>
</tr>
<tr>
<td>Total emissions (natural + anthropogenic; Cd, Pb, N)</td>
<td>50 km x 50 km</td>
<td>MSC-WEST(^3)/East(^4)</td>
</tr>
<tr>
<td>Total deposition (Cd, Hg, Pb, N)</td>
<td>50 km x 50 km</td>
<td>MSC-WEST(^3)/East(^4)</td>
</tr>
</tbody>
</table>

\(^1\) Climatic Research Unit, www.cru.uea.ac.uk
\(^3\) Meteorological Synthesizing Centre-West of EMEP, http://met.no
\(^4\) Meteorological Synthesizing Centre-East of EMEP, http://www.msceast.org
Methodology

**Dependent variable**
Element concentrations

**Predictors**
Site-specific (Moss species ...)
Regional (Depositions, Land use ...)

**Point data**
- GIS-Intersection
- Spatial Join to ELCE Units

**Raster data**
- Spectral data
- Remote Sensing

**Spearman Rank Correlation**

**Classification and Regression Trees**

- Waldflächen im 5 km Radius [-]
- Urbane Flächen im 300 m Radius [+]
- Urbane Flächen im 1 km Radius [+]
- Urbane Flächen im 5 km Radius [+]
- Verkehrsflächen im 1 km Radius [+]
- Verkehrsflächen im 5 km Radius [+]
- Agrarfächen im 300 m Radius [+]
- Agrarfächen im 1 km Radius [+]
- Agrarfächen im 5 km Radius [+]
- Niederschlagssumme 09.2006 [-]
- Niederschlagssumme 10.2006 [-]
- Niederschlagssumme 2004 - 2006 [-]
- Niederschlagssumme 2003 - 2006 [-]
- Distanz zum Meer [-]
- Höhe ü. NN [-]
- Neigung [-]
- Bestandeshöhe [-]
- Entfernung zur Baumkrone [+]
- Entfernung zum Strauch [+]
- Entfernung zur Wohnsiedlung [-]
- Entfernung zur Landstraße [-]
- Entfernung zur Autobahn [+]
- Entfernung zur landw. Nutzfläche [-]
- Entfernung zur Industrieanlage [+]
- Hintergrundwerte im Oberboden [-]
- Kontam. durch Kalkpartikel [+]

Note: The diagram includes various data sources and analysis methods used in the methodology, illustrating the integration of point and raster data through GIS techniques and statistical analysis.
Results: Correlations $\text{Cd (Moss)} - \text{Cd (Dep)}$ within ELCE Units

Calculations performed for all ELCE units with $n > 10$
Results: Correlations Pb (Moss) – Pb (Dep) within ELCE Units

Calculations performed for all ELCE units with n > 10
Results: Correlations Hg (Moss) – Hg (Dep) within ELCE Units

Calculations performed for all ELCE units with n > 10

Spearman Correlations Hg

> 0.89
0.7 - 0.89
0.5 - 0.69
0.2 - 0.49
< 0.2
Results: Correlations $N$ (Moss) – $N$ (Dep) within ELCE Units

Calculations performed for all ELCE units with $n > 10$
Results: Decision Tree Analysis for N in Mosses within ELCE Units

F_1.2 - Correlation 0.58*
F_4.2 - Correlation 0.01
* Significant (p < 0.01)
Results: Decision Tree Analysis for ELCE Unit F_1.2

CART analysis for ELCE class F_1.2
N = 236
62 % explained variance
High correlation!
Results: Decision Tree Analysis ELCE Unit F_4.2 (N)

CART analysis for ELCE class F_4.2

N = 396
10% explained variance
Low correlation!
Results: *Enough Sites within ELCE Units?*

Minimum Sample Size (MSS)

\[ MSS = \left( \frac{Stdev \times 1.96}{0.2 \times Mean} \right)^2 \]

<table>
<thead>
<tr>
<th>Number of ELCE units with missing sites</th>
<th>Cd</th>
<th>Hg</th>
<th>Pb</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 / 29</td>
<td>3 / 26</td>
<td>11 / 29</td>
<td>3 / 27</td>
</tr>
<tr>
<td>Area covered by ELCE units with missing sites [km²]</td>
<td>498186.7</td>
<td>105844.8</td>
<td>858911.5</td>
<td>78563.0</td>
</tr>
<tr>
<td></td>
<td>24.1 %</td>
<td>11.5 %</td>
<td>37.9 %</td>
<td>11.1 %</td>
</tr>
<tr>
<td></td>
<td>12.3 %</td>
<td>4.2 %</td>
<td>21.5 %</td>
<td>3.3 %</td>
</tr>
</tbody>
</table>
Conclusions

Landscape-specific correlations between Cd, Hg, Pb, N in mosses and depositions

*ELCE* units with high and low correlations for Cd, Hg, Pb, N

Spatial correlation patterns differ for Cd, Hg, Pb and N

More detailed multivariate investigations needed

Minimum number of sites not achieved for some ELCE units → Optimizing spatial design of Moss Survey?
Respective strategy tested in Germany (Pesch et al. 2006)
Thank you for your attention!


Schröder W et al. Are cadmium, lead and mercury concentrations in mosses across Europe primarily determined by atmospheric deposition of these metals? *J Soils Sediments* 2010, 10:1572-1584

