INTEGRATIVE ASSESSMENT OF DATA MEASURED BY BIOMONITORING AND CALCULATED BY USE OF MODELS INDICATING ATMOSPHERIC DEPOSITION OF HEAVY METALS

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Keywords: EMEP; Environmental Specimen Bank; European Moss Survey; ICP Forests; LOTOS-EUROS

Introduction

Atmospheric deposition of heavy metals (HM) can be determined by use of numeric models, technical devices and biomonitors. A compilation and integrative statistical assessment is still missing. Therefore, mainly focussing on Germany as an example, this paper aims at statistically assess HM data from deposition modelling and biomonitoring programmes (Nickel and Schröder 2016).

Methods

The model LOTOS-EUROS (LE) yielded data on HM deposition at a spatial resolution of 25 km by 25 km throughout Europe. The European Monitoring and Evaluation Programme (EMEP) provided model calculations on 50 km by 50 km grids. Corresponding data on HM concentration in moss, leaves and needles and soil were derived from the European Moss Survey (EMS), the German Environmental Specimen Bank (ESB) and the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests). The modelled HM deposition and respective concentrations in moss (EMS), leaves and needles (ESB, ICP Forests) and soil (ICP Forests) were investigated for their statistical relationships. Regression equations were applied on geostatistical surface estimations of HM concentration in moss and then the residuals were interpolated by use of kriging interpolation. Both maps were summed up to a map of cadmium (Cd) and lead (Pb) deposition across Germany.

Results

HM concentrations in biomonitors (moss, leaves, needles) were found to be predominantly higher correlated to deposition modelled by LE compared to EMEP (Table 1). For Cd, strongest correlations could be found between deposition data calculated by LE and concentrations in moss (Europe, geostatistically estimated) and needles (Germany). Regarding Pb, the coefficients of correlation came out to be the highest for EMEP deposition and element concentrations in moss (Europe, geostatistically estimated) and leaves from ICP Forests Level II (Germany) and, respectively, LE deposition and leaves from ESB (Germany).

Proceedings of the 18th International Conference on Heavy Metals in the Environment, 12 to 15 September 2016, Ghent, Belgium

Table 1. Coefficients of correlation of Cd and Pb concentrations in biomonitors and respective total atmospheric deposition (LE, EMEP) in Europe and Germany

Biomonitoring network / Specimen type	Element	$r_{(LE)}$	$r_{(EMEP)}$
European Moss Survey (2005/2006)			
Moss, measured conc. (Germany)	Cd	0.31	0.27
Moss, measured conc. (Europe)	Cd	0.66	0.59
Moss, measured conc. (Germany)	Pb	0.35	0.31
Moss, measured conc. (Europe)	Pb	0.56	0.65
Moss, geostatistically estimated conc. (Germany)	Cd	0.37	0.43
Moss, geostatistically estimated conc. (Europe)	Cd	0.81	0.70
Moss, geostatistically estimated conc. (Germany)	Pb	0.49	0.44
Moss, geostatistically estimated conc. (Europe)	Pb	0.42	0.57
German Environmental Specimen Bank (2007-2011)			
Beech (*Fagus sylvatica*)	Cd	0.29	0.23*
Poplar (*Populus nigra 'Italica'*)	Cd	0.36	0.26*
Spruce (*Picea abies*), nearly natural ecosystems	Cd	0.49	0.36*
Spruce (*Picea abies*), forestry ecosystems	Cd	0.64	0.40*
Beech (*Fagus sylvatica*)	Pb	0.44	0.43
Poplar (*Populus nigra 'Italica'*)	Pb	0.63	0.44
Spruce (*Picea abies*)	Pb	0.29	0.27
ICP Forest Level II (2007-2011)			
Beech (*Fagus sylvatica*)	Cd	-0.03*	0.21
Spruce (*Picea abies*)	Cd	0.21	0.28
Pine (*Pinus sylvestris*)	Cd	0.34	0.08*
Beech (*Fagus sylvatica*)	Pb	0.26	0.40
Spruce (*Picea abies*)	Pb	0.19	0.30
Pine (*Pinus sylvestris*)	Pb	0.18	0.20

N = Sample size; r = Spearman's correlation coefficient calculated for EMS-data; Kendall's correlation coefficient for data from ESB and ICP Forests; $r_{(LE)}$ = with regard to the relationships between biomonitoring data and LOTOS-EUROS; $r_{(EMEP)}$ = with regard to the relationships between biomonitoring data and EMEP; * = not significant ($p > 0.05$)

Conclusion

Beyond the statistical relationships explored between HM concentrations in biomonitors, potential predictors such as distance from emission sources, density of different land-use classes, population density, elevation or precipitation should be further investigated by multivariate statistics (e.g. Principal component analysis, Random Forests). Exposure data from biomonitoring and deposition modelling should complement forest monitoring and assessments and linked with ecological land classifications and ecosystem typologies (Schröder et al. 2015).

References

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