Evaluation of Gothenburg protocol and global change on acidification and eutrophication of soil and water

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Gothenburg Protocol (UN ECE, 1998)
Protocol to Abate Acidification, Eutrophication and Ground Level Ozon

NO$_x$ and SO$_2$ emissions in the Czech Republic (1980-2002)

Target emissions according Gothenburg Protocol
Atmospheric deposition – western CZ

Sulfur
Nitrogen

kg/ha/year

The effect on atmosphere is clearly positive – but how ecosystems respond?

1. **Soil and water regeneration** – small catchments and lakes monitoring and dynamic modeling according protocol predictions

2. **Mapping of streamwater chemistry** (prior the Protocol and after that)

3. **Critical loads for acidity and eutrofication** (prior the Protocol and after that) – response of forest health

4. **How global change affect regeneration?**
Small catchments network **GEOMON** (deposition, soils, streams, forest health)  
- at minimum 11 years of data (27 years the longest record)  
- excellent tool for monitoring and modeling of long-term responses
Streamwater $\text{SO}_4$ (mg/L) 1990-2002 – decline due to protocols application
Streamwater pH 1990-2002

- Pluhuv Bor
- Lysina
Soil and water future (and history)?

Biogeochemical modeling by MAGIC model (NIVA)

MAGIC (Model of Acidification of Groundwater in Catchments):

• **Inputs:** atmospheric deposition (PROTOCOLS), actual soil chemistry and water chemistry

• **Results:** Long-term trends of soil and water chemistry for the past and the future
The graph shows the historical analysis of sulfate levels from 1892 for Lysina and Pluhuv Bor. The y-axis represents the sulfate concentration in µeq/L, while the x-axis represents the year from 1850 to 2030. The data is represented by different markers: grey circles for Data Lysina, white circles for Data Pluhuv Bor, red line for MAGIC - Lysina, and blue line for MAGIC - Pluhuv Bor. The graph highlights the peak sulfate levels in the 1970s and the subsequent decline into the 2000s.
Soil base saturation – NO REGENERATION until 2030

- Data Lysina
- Data - Pluhuv Bor
- MAGIC - Lysina
- MAGIC - Pluhuv Bor

Year

Soil base saturation (%)
Bohemian Forest lakes – delayed biological recovery

![Graph showing the decline in crustacean species and pH over time. The graph indicates a sharp drop in crustacean species and a rise in pH, particularly after 1980. The specific species mentioned are Planktonic crustacea and Ceriodaphnia quadrangula.](image-url)
Stream water pH at 1980s/1990s (prior GP)
Cadmium at 1980s/1990s (prior GP)
2. CRITICAL LOAD for sulfur and nitrogen

CL is a level of atmospheric deposition which does not have long-term harmful effect on the most sensitive part of ecosystem (forest soil)
Exceedance of critical load for acidity (Skořepová, 1999)

Celkové překročení kritické zátěže síry a dusíku pro lesní ekosystémy
Exceedance of eutrophying nitrogen critical load (Skořepová, 1999)

Překročení kritické zátěže dusíku pro lesní ekosystémy

- <= 0 eq.ha-1.rok-1
- 1 - 999 eq.ha-1.rok-1
- 1000 - 1999 eq.ha-1.rok-1
- 2000 - 2999 eq.ha-1.rok-1
- 3000 - 3400 eq.ha-1.rok-1
Proposed work 2005-2009 (cooperation with NIVA):

1. Evaluation and modeling of long-term observations (catchment and lakes) using GP scenario
2. Re-mapping of streamwaters in sensitive areas
3. Specific spatial modeling of further necessary reduction of S and N deposition (prioritising between measures and sources)
4. Recommendation for the next protocol (cost efficiency reduction)
5. New topic – global warming effect on acidification and eutrophication
Effect of climate change??

Variations of the Earth's surface temperature: year 1000 to year 2100

Departures in temperature in °C (from the 1990 value)

Observations, Northern Hemisphere, proxy data

Climate instrumental observations

Projections

Several models all SRES envelope

Data show the range in year 2100 projected by several models

Scenarios:
- A1B
- A1T
- A1T
- A2
- B1
- E2
- IS92a
Schematic View of the MAGIC Model

Atmospheric Deposition

Exchangeable Cations and Sulfate In Soil

Soil Solution

Ions in Tree Biomass

Net Uptake

CO₂

Chemical Weathering

Stream or Lake

RCOOH

CO₂
Forest defoliation did not change significantly
Model tools for prioritising emission measures

- Within the framework of the LRTAP Convention has emission reduction measures been prioritised both according to costs and environmental benefits.
- For prioritising between measures on single installation (industries, powerplants, etc…) a modified approach from the same concept (emission to deposition modelling and critical loads) can be developed.
- Development of such methodology can guide to cost efficient measures with the optimal environmental improvement.
- Conceptually, the approach can be used for emissions to air, water and soils.
- Available survey data and tools from LRTAP Convention work make a good foundation for the development.