TFEIP & ESPREME Workshop
Heavy Metals and POPs

Rovaniemi, 18-19 October, 2005

Observations, Conclusions, and Recommendations
General observations

- Further progress has been made in assessing sources and emissions of HMs and POPs to the atmosphere at a country and regional (European) level.

- National reporting of HM and POP emissions to the UN ECE LRTAP has improved but still several Parties do not comply with the reporting requests.

- At least 3 European wide emission inventories have been presented by groups of emission experts for the reference year 2000: ESPREME (for HMs), TNO (HMs and POPs), and MSC-E (HMs and POPs).

- Emission estimates prepared by expert groups are higher than the estimates provided by countries (so-called official estimates).
Available emissions data

- No temporal variation
- No speciation (Hg)
- No height of emission sources
- No size distribution of emitted particles
Emissions vs. measured depositions

Total emissions and total wet deposition in Europe (2000)

Pb

Cd

Total wet depositions over land exceed total anthropogenic emissions

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Measurements vs. modelling results

**Pb concentrations in air**
(2003)

Modelling results based on **official emissions** data

Model underestimates measurements by a factor ~2-3

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General observations

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- At least 3 European wide emission inventories have been presented by groups of emission experts for the reference year 2000: ESPREME (for HMs), TNO (HMs and POPs), and MSC-E (HMs and POPs)

- Emission estimates prepared by expert groups are higher than the estimates provided by countries (so-called official estimates)
### Emissions of As, Cd, Cr, Ni and Pb in Europe in the year 2000

<table>
<thead>
<tr>
<th>Source Category</th>
<th>As</th>
<th>Cr</th>
<th>Ni</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons</td>
<td>%</td>
<td>tons</td>
<td>%</td>
</tr>
<tr>
<td>1. Combustion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- stationary sources</td>
<td>391</td>
<td>51</td>
<td>367</td>
<td>63</td>
</tr>
<tr>
<td>- mobile sources</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Industrial processes</td>
<td>279</td>
<td>37</td>
<td>162</td>
<td>27</td>
</tr>
<tr>
<td>3. Other sources</td>
<td>93</td>
<td>12</td>
<td>61</td>
<td>10</td>
</tr>
<tr>
<td>TOTAL</td>
<td>763</td>
<td>100</td>
<td>590</td>
<td>100</td>
</tr>
</tbody>
</table>
Emissions are available as input for modelling -

Example

Distribution of the emissions of cadmium over the 50 x 50 km² EMEP grid for UNECE-Europe in 2000 (kg/grid cell)
Development of critical loads approach

Pb deposition flux to coniferous forest (2000)

Official emissions data

Adjusted emissions scenario

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General observations

- Continuous reduction of HM and selected POP emissions in Europe during the last few decades: implementation of regulations, economic decline

- Potential for further reduction until the years 2010/2020: approaches to develop future emission scenarios in focus,

- Major sources of HM and POP emissions are fairly well identified: continuous progress, measurements at main sources

- Waste disposal and biomass combustion are underestimated as sources of selected HM and POP releases to the atmosphere, water, and land: old problem still waiting solution
Change of anthropogenic emissions of total mercury to the atmosphere in Europe from 1980 through 2000 (in tonnes)
Historical view of PL at coal-fired power plants in the Netherlands

<table>
<thead>
<tr>
<th>Collection Device</th>
<th>Efficiency</th>
<th>Conc. in mg.m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-1980 modaves, cyclones, ESP</td>
<td>90-95-99%</td>
<td>&lt; 1000</td>
</tr>
<tr>
<td>1980-1990 high efficiency ESP</td>
<td>99.9%</td>
<td>&lt; 100</td>
</tr>
<tr>
<td>1990-2000 ESP+wet FGD</td>
<td>99.96%</td>
<td>&lt; 10</td>
</tr>
</tbody>
</table>

PL = particulate loading (dust concentration)
PCDDs, PCDFs and co-PCBs

- In 1999, established the national emission inventory for 1997
- Set emission reduction target of 95% by 2003
- In 2005, revised the reduction plan

National emission of PCDDs, PCDFs and co-PCBs (g-TEQ)

<table>
<thead>
<tr>
<th></th>
<th>1997</th>
<th>2003</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total emission</td>
<td>7,680-8,135</td>
<td>372-400</td>
<td>315-343</td>
</tr>
</tbody>
</table>
Projected Trends in Hg Emissions - CAMR

- **1990**
  - Other Categories: 220 tpy
  - Gold Mines: 112 tpy
  - Haz Waste Incin: 78 tpy

- **1999**
  - Other Categories: 112 tpy
  - Gold Mines: 78 tpy
  - Haz Waste Incin: 50 tpy
  - Choralkali: 30 tpy

- **2020**
  - Other Categories: 78 tpy
  - Gold Mines: 50 tpy
  - Haz Waste Incin: 30 tpy
  - Choralkali: 20 tpy
  - Ind Boilers: 10 tpy
  - Mun Waste Comb: 5 tpy
  - Med Waste Incin: 3 tpy
  - Utility Coal: 2 tpy
The 2010 emission scenarios for As, Cd, Cr, Ni and Pb in Europe
Results: (1) Source-specific emission factors

Arsenic Emission Factors from Lignite Combustion in different Source Sectors, 1990-2010

As Emission Factor [g/TJ]

- Public Power Plants
- German Railway
- Lignite Mining
- Other Industrial Power Plants
- District Heating Plants

Year

The difference between projected cadmium emissions from UNECE-Europe in the year 2010 and the emission inventory for the year 2000 (negative values indicate an emission reduction) (kg/grid cell)
General observations

- Continuous reduction of HM and selected POP emissions in Europe during the last few decades: implementation of regulations, economic decline

- Potential for further reduction until the years 2010/2020: approaches to develop future emission scenarios in focus,

- Major sources of HM and POP emissions are fairly well identified: continuous progress, measurements at main sources

- Waste disposal and biomass combustion are underestimated as sources of selected HM and POP releases to the atmosphere, water, and land: old problem still waiting solution
View of Dutch and European legislation with respect to emissions into the air for coal-fired power plants, and co-combustion for new installations (4/4)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EC</td>
<td>NL</td>
<td>stand alone</td>
<td>co-comb 2) $C_{coal}/C_{waste}$</td>
</tr>
<tr>
<td>% $O_2$</td>
<td>6</td>
<td>6</td>
<td>11</td>
<td>(6)</td>
</tr>
<tr>
<td>$SO_2$</td>
<td>200</td>
<td>200</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>$NO_x$ 6)</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>CO</td>
<td></td>
<td></td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>PM</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>HCl</td>
<td></td>
<td></td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>HF</td>
<td></td>
<td></td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>VOC</td>
<td></td>
<td></td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>$\Sigma$ 9 HM 3)</td>
<td></td>
<td></td>
<td>0.5</td>
<td>0.75</td>
</tr>
<tr>
<td>Cd + Tl</td>
<td>0.05</td>
<td>0.075</td>
<td>0.05</td>
<td>0.075</td>
</tr>
<tr>
<td>Hg</td>
<td>0.05</td>
<td>0.075</td>
<td>0.05</td>
<td>0.075</td>
</tr>
<tr>
<td>PCDDs/PCDFs (ng TEQ•m$^{-3}$)</td>
<td>0.1</td>
<td>0.15</td>
<td>0.1</td>
<td>0.15</td>
</tr>
</tbody>
</table>
PAHs Liguria case study

- emissions variation depend largely from the reduction in steel production (one single large electric furnace steel plant)
- forest fires (the main source of emissions) show large variation between years due to different extension of fires
Distribution on types of filters for waste incineration plants

- Wet, ESP: 27%
- Wet, ESP and FB: 36%
- Dry, ES: 0%
- Not known: 6%
- Dry, FB: 5%
- Wet, FB: 3%
- Semidry, CYK and FB: 7%
- Semidry, FB: 16%
Needs for use of other data

1. Use of global emission inventories

2. Use of emissions inventories for natural sources
Modelling of mercury pollution

Hg pollution levels in Europe

Hemispheric modelling

Global emissions estimates

TFEIP & ESPREME Workshop, Rovaniemi, 2005
Comparison of Global Anthropogenic Emissions of Trace Metals in the mid-1990s with Emissions from natural sources estimated by Richardson, 2001

<table>
<thead>
<tr>
<th>Trace Metal</th>
<th>Anthropogenic emissions (median values)</th>
<th>Natural emissions (lower 95th C.I.)</th>
<th>Anthropogenic/natural ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>3.0</td>
<td>36</td>
<td>0.08 – 0.2</td>
</tr>
<tr>
<td>Cu</td>
<td>25.9</td>
<td>1500</td>
<td>0.02 – 0.1</td>
</tr>
<tr>
<td>Ni</td>
<td>95.3</td>
<td>1300</td>
<td>0.07 – 0.4</td>
</tr>
<tr>
<td>Pb</td>
<td>119.3</td>
<td>1300</td>
<td>0.09 – 0.4</td>
</tr>
<tr>
<td>Zn</td>
<td>57</td>
<td>4700</td>
<td>0.01 – 0.05</td>
</tr>
</tbody>
</table>

Emissions in $10^6$ kg/year
New Compounds

- Approaches to select new compounds
- Problems with collecting input data for emission inventory
### New-Substances

<table>
<thead>
<tr>
<th>Substances possibly proposed to be added to the POP Protocol ('new-substances')</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dicofol</strong></td>
</tr>
<tr>
<td>Endosulfan</td>
</tr>
<tr>
<td>Hexachlorobutadiene (HBU)</td>
</tr>
<tr>
<td><strong>Pentabromodiphenyl ether (PBDE)</strong></td>
</tr>
<tr>
<td>Pentachlorobenzene (PCBe)</td>
</tr>
<tr>
<td>Pentachlorophenol (PCP)</td>
</tr>
<tr>
<td><strong>Polychloronated naftalenes (PCN)</strong></td>
</tr>
<tr>
<td>Short chained chlorinated paraffin’s (SCCPs)</td>
</tr>
</tbody>
</table>
Gridded emission

Distribution of the emission of Dicofol on the EMEP grid for UNECE-Europe for year 2000 (kg/gridcell)
Conclusions:
Needs for improvement

- National experts should concentrate on closing deficiency of their data reporting with regard to:
  - source sector completeness,
  - spatial distribution; emission maps,
  - temporal variations,
  - chemical speciation,
  - height of emission point sources,
  - chemically speciated particle size distribution,
  - accuracy estimates
Emission profiles for different chemical forms of mercury and various source categories

- Power plants
- Residential heat
- Cement Production
- Lead
- Zinc
- Pig & iron
- Waste Disposal

- Hg (partic.)
- HgII
- Hg0 (gas)
Uncertainty analysis

Three approaches

- Sensitivity to a specific parameter / emission factor
- Sensitivity to technology selection
- Monte Carlo uncertainty analysis
Conclusions

Needs for improvement

- Improvement of information available in the Atmospheric Emission Inventory Guidebook

- More emission measurements for the improvement of emission factor quality

- Integration of information available in the European scale inventories e.g. ESPREME, TNO, MSC-E for a research-based 2000 emission inventory for HMs and POPs to the air in Europe
Conclusions

Needs for improvement

- Improvement of information on releases of HMs and POPs to water and land in Europe

- Integration of information available in the European scale inventories e.g. within various EU projects for a research-based 2000 emission inventory for HMs and POPs to water and land in Europe
Recommendations

- The EMEP modelers are recommended to use the research based emission inventories for HMs and POPs, e.g. ESPREME, TNO, MSC-E in their estimates of concentrations, deposition, and critical load until more complete and accurate official data from various countries are available.

- Integration of information available in the European scale inventories, such as ESPREME, TNO, MSC-E for 2000 emission inventory and future scenarios for HMs and POPs in the air in Europe is recommended and should be coordinated by the EMEP CCC.
Recommendations

- National emission experts are recommended to analyze the research based emission inventories and contribute to closing eventual gaps between the official and research based data.