Risk Habitat Megacity

Air Quality and Health

Speaker: Peter Suppan (KIT/IMK-IFU) & Rainer Schmitz (UCH)
Involved scientists: Frank Baier (DLR), Ulrich Franck, Arne Leitte (UFZ), Ricardo Muñoz (UCH)
Renate Forkel, Johannes Werhahn, Martin Nogalski (KIT/IMK-IFU)
1. Problem Analysis – What are the risks?

2. Methodological Approach

3. Insights on the Development of Traffic Emissions

4. Results
Do we understand the complex links between emissions, air quality and health impact? Where and what is at risk in this chain?

How can suitable emission inventories for reliable air quality assessment studies be developed? What is the part of the traffic?

How can separate information platforms be linked to the development of an integrated approach to air quality assessment in megacities? What are the indicators to define the risk?

Which relationship exists between specific air pollutants like PM_{10} or NO_{2} and the appearance of environment-related diseases? What are the risk levels?
Status analysis of the risks on air pollution

- **NO₂**: 100 µg/m³ annual mean
- **PM₁₀**: 50 µg/m³ annual mean
- **O₃**: 160 µg/m³ 1 hour mean

Source: CONAMA
Status analysis of the risks on air pollution

Annual average PM$_{10}$ concentrations ($\mu$g/m$^3$)

Comparison of Megacites

M. Krzyzanowski, H-G. Mucke, WHO, 2009
Status analysis of the risks on air pollution

Air Quality & Health

PM$_{10}$

<table>
<thead>
<tr>
<th>2004</th>
<th>Pudahuel</th>
<th>La Florida</th>
<th>Parque O'Higgins</th>
<th>Las Condes</th>
<th>Cerrillos</th>
<th>El Bosque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>67.1</td>
<td>80.7</td>
<td>67.9</td>
<td>52.5</td>
<td>67.9</td>
<td>77.1</td>
</tr>
<tr>
<td>95 %</td>
<td>164.0</td>
<td>203.0</td>
<td>162.0</td>
<td>115.0</td>
<td>166.0</td>
<td>185.0</td>
</tr>
</tbody>
</table>

O$_3$

<table>
<thead>
<tr>
<th>2004</th>
<th>Pudahuel</th>
<th>La Florida</th>
<th>Parque O'Higgins</th>
<th>Las Condes</th>
<th>Cerrillos</th>
<th>El Bosque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>16.5</td>
<td>17.3</td>
<td>15.6</td>
<td>20.6</td>
<td>15.9</td>
<td>19.0</td>
</tr>
<tr>
<td>95 %</td>
<td>50.4</td>
<td>58.2</td>
<td>56.3</td>
<td>74.4</td>
<td>51.5</td>
<td>51.8</td>
</tr>
</tbody>
</table>

Source: CONAMA-Database
Status analysis of the risks on air pollution

Air Quality & Health

Emission Sources

PM$_{10}$

NO$_x$

Source: CONAMA-CENMA, 2007
<table>
<thead>
<tr>
<th>Air Quality &amp; Health</th>
<th>Area Emissions</th>
<th>Mobile Emissions</th>
</tr>
</thead>
</table>

Status analysis of the risks on air pollution

Up to date emission inventory (April 2010) for NO
Methodological Approach

- Satellite Data
- Measurement Data
- Traffic Data

Air Quality Indicators
- Air Pollutants - Mortality rates
- Elements at Risk
- Health Impact

Scenarios
- Stakeholder
- Mortality rates
- Sulphur compounds
- Health impacts

Traffic Data
Results: Micro Scale - Traffic Emissions

ESTRAUS
• total vehicle flow
• street network

Emission factors
• experimental results

Vehicular disaggregation
• fleet composition

Temporal disaggregation
• Driving profiles

Annual Emissions

Hourly Emissions

\[ E_{ijk}[g] = TF_j[veh/h] \times L_j[km] \times VD_{jk} \times TF_{jk} \times EF_{[g/km]}_{ik} \]

Simulation of traffic emissions

Cooperation with FoA Transportation
Results: Micro Scale - Traffic Emissions

61 vehicle categories
- Buses licitados Diesel convencional
- Buses licitados Diesel tipo 1
- Buses licitados Diesel tipo 2
- Buses licitados Diesel tipo 3
- Buses licitados Diesel tipo 3 Articulado
- Buses licitados Diesel tipo 2 con filtro
- Buses licitados Diesel tipo 3 con filtro
- Buses Interurbanos Diesel convencional
- Buses Interurbanos Diesel tipo 1
- Buses Alimentador Diesel tipo 2
- Buses Alimentador Diesel tipo 3
- Buses Alimentador Diesel tipo 3 con filtro

5 categories of emissions
- cold emissions
- hot emissions
- evaporation
- resuspension (abrasion tyres, abrasion brakes)

6 emission pollutants
- PM10
- SO2
- NOx
- HC
- CO
- CO2
- [Gasoline consumption]

3 scenarios
Results: Micro Scale - Traffic Emissions

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**NOx**
- Conv
- Tipo 1
- Tipo 2
- Tipo 3
- Tipo 4
- Tipo 5
- Tipo 6

[g/km]

**PM10**
- Conv
- Tipo 1
- Tipo 2
- Tipo 3
- Tipo 4
- Tipo 5
- Tipo 6

[g/km]

[km/h]

**Busses**

[km/h]

**Passenger Cars**
Results: Micro Scale - Traffic Emissions

Simulated NOx distribution of traffic emissions

NOx in µg/m³
Results: Micro Scale - Traffic Emissions

Simulated NOx distribution of traffic emissions

NOx in µg/m³
Results: Traffic Emissions

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Traffic Emissions and Comunas

PM$_{10}$

NOx
Maximal daily risk increase per 10 µg/m³ PM10

**Results: Health Impact**

Maximum Mortality Risks (OR) per 10 µg/m³ PM₁₀

Reduction benefit of PM₁₀ is about $2 Bill. in Mexico City (Molina & Molina, 2002)
Results: Health Impact

Maximum Mortality Risks (OR) per 1 µg/m³ PM$_{10}$

I30 - I51 (other heart diseases)
Conclusions

Complex link between emissions, air quality and health impact is fairly understood - **at risk are not only human beings but also plants, building/cultural heritages**

- Development of emission inventories is a very demanding challenge in terms of input data - **could be demonstrated with traffic emissions**

- Separate air quality platforms can be linked - **basic prerequisite for the definition of indicators**

- Clear relationships exist between PM$_{10}$ and the appearance of environment-related diseases - **risks levels for PM$_{10}$ did not exist**

...many questions are still not finally answered...
### Air Quality & Health

#### Scenarios – First Results

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>132.1 kt/a</td>
<td>34.5 kt/a</td>
</tr>
<tr>
<td>HC</td>
<td>13 kt/a</td>
<td>1.7 kt/a</td>
</tr>
<tr>
<td>NOX</td>
<td>34.2 kt/a</td>
<td>9.8 kt/a</td>
</tr>
<tr>
<td>PM10</td>
<td>1.2 kt/a</td>
<td>0.7 kt/a</td>
</tr>
<tr>
<td>PM2.5</td>
<td>0.8 kt/a</td>
<td>0.2 kt/a</td>
</tr>
</tbody>
</table>

**Traffic Scenario BAU**
Thank you for your attention

....but also for the very fruitful cooperation and discussions.....