How can Vegetation Impact Air Pollution Control in the Central Valley of Mexico?

Rainer Steinbrecher

Biogenic VOC and Sources

Biogenic VOC and the Atmosphere

Biogenic VOC and Mexico City

Plants and Urban Atmospheres

Synopsis: Plants in Cities

Outlook: Greening Mexico City
Biogenic VOC and Sources

Isoprenoides

- Isoprene
- α-Pinene
- β-Pinene
- Δ²-Carene
- Sabinene
- Limonene
- β-Phellandrene
- Myrcene
- p-Cymene
- Camphene
- 1,8 Cineol
- trans-β-Ocimene
- trans-β-Caryophyllene

Oxygen Containing Compounds

- Methanol
- Ethanol
- 2-Methyl-3-buten-2-ol
- Acetaldehyde
- Acetone
Biogenic VOC and Sources

Europe Antropogenic VOC – 2000 [Mg]

Europe Biogenic VOC – 2000 [Mg]

(Curci, Beekmann et al. 2008)
Biogenic VOC and Sources


(Steinbrecher, Smiatek et al. 2008)

Emission > 1.5 t km\(^{-2}\) yr\(^{-1}\)
Biogenic VOC and the Atmosphere

Ozone
NO\textsubscript{x}
VOC

Light
Water Vapor

Radicals
(O\textsubscript{3}, HO, NO\textsubscript{3}, org-R)
PAN
CO, etc

(ESPERE, 2006)
Biogenic VOC and the Atmosphere

Ozone
BVOC

Pinus taeda

O$_3$ ~ 20 ppb

(VanReken et al. 2006)
Biogenic VOC and the Atmosphere

NatAir Emissions and Air Quality in Europe with CHIMERE

Surface Ozone Max NO BVOC – JJA 2000

Change with NatAir BVOCs

[Curci, Beekmann et al. 2008]
Biogenic VOC and the Atmosphere

NatAir Emissions and Air Quality in Europe with CHIMERE

PM10 mean CTRL JJA 2000 [ug/m3]

No BVOC

BVOC Contribution

(Curci, Beekmann et al. 2008)
## Biogenic VOC and Mexico City

<table>
<thead>
<tr>
<th></th>
<th>Área km² (*)</th>
<th>Total áreas verdes km²</th>
<th>Áreas verdes %</th>
<th>% Zonas arboladas</th>
<th>Áreas verdes por habitante km²</th>
<th>Zonas arboladas por habitante m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.F.</td>
<td>632.66</td>
<td>128.28</td>
<td>20.4</td>
<td>55.9</td>
<td>44.1</td>
<td>15.1</td>
</tr>
</tbody>
</table>
Biogenic VOC and Mexico City

Abies religiosa

Day light vs dark

Monterpene flux [ug C g \(^{-1}\) dw h \(^{-1}\)]

γ-terpinene
limonene
β-pinene
α-pinene

Time [h]

1 2 3

(Dominguez, Ruiz et al. 2007)
The new isoprenoid emission factors will correct current biogenic VOC inventories with consequences for air quality modeling.

This may partly explain the high fraction of biogenics in OC of particles for this area (Szidat et al., 2007).
Plants and Urban Atmospheres

Temperature Reduction and other Microclimate Effects

Removal of Air Pollutants

Energy Effects on Buildings

Emission of VOC and tree maintenance emissions

(Nowak and Crane, 1998)
Modular Urban Forest Effects (UFORE) Model

**UFORE-A**: Anatomy of the Urban Forest – quantifies urban forest structure (species composition, density, tree health, leaf area, leaf and tree biomass).

**UFORE-B**: Biogenic Volatile Organic Compound (VOC) emissions – quantifies hourly urban forest VOC emissions (isoprene, monoterpenes and other VOC emissions that contribute to ozone formation) and ozone and CO formation based on VOC emission.

**UFORE-C**: Carbon Storage and Sequestration – calculates total carbon (C) storage potential and gross and net C sequestered annual by the urban forest based on field data.

**UFORE-D**: Dry Deposition of Air Pollution – quantifies the hourly amount of pollution removed by the urban vegetation and the associated per cent improvement in air quality through out a year. Pollution removal is calculated for $O_3$, $SO_2$, $NO_2$, $CO$ and $PM_{10}$.

(Nowak and Crane, 1998)
Plants and Urban Atmospheres

Toronto: Annual Pollutant Deposition with UFORE

(Curie and Bass; brad.bass@ec.gc.ca)
Plants and Urban Atmospheres

**UK Midlands**: Particle Deposition with FRAME (Base 1998; PM10) (Fine Resolution Atmospheric Multi-Pollutant Exchange Model)

(FPP: Future planting Potential)

(McDonald et al. 2007)
Plants and Urban Atmospheres

- Reduce Air Pollution
- Reduce Heat Islands
- Socioeconomic Benefits

Roof Greening
Roof Gardens
Plants and Urban Atmospheres

Temperatures

[Graph showing temperatures over time for different surfaces: Surface Black roof, Surface Green roof, Sealing Green roof, Air 0m Green roof, and Air 1m Green roof. The graph indicates that the temperature of the Surface Black roof is significantly higher than the other surfaces, especially during the afternoon hours.]
Plants and Urban Atmospheres

Temperatures

**Extensive Greened Roof**

Energy balance, daily mean

- **Advantages**
  - Improvement of the microclimate
  - High durability of the sealing of the roof
  - Reduction of the runoff by evapotranspiration

- **Global Radiation** 5354 Wh
- **Reflection** 803 Wh
- **Evaporation-cooling** 1185 Wh
- **Latent Heat** 872 Wh

**Main Influencing Factors:**
- Field capacity of the soil
- Exposition
- Percentage of cover of the vegetation

**Increased Thermal Radiation** 2494 Wh

**Thermal Radiation Balance** 7555 Wh

**Radiation Balance** 2057 Wh

Ω Daily Mean in Wh/m² June-August 2000
UFA-Fabrik Berlin-Tempelhof
Plants and Urban Atmospheres

Cooling effect of adding tree cover to a city in a hot dry climate zone.

Huang et al., Lawrence Berkeley Laboratory, USA
Plants and Urban Atmospheres

Estimated Annual Energy Savings
Seattle, Washington

http://epa.gov/heatisland/resources/tools.html
Synopsis: Plants in Cities

- Increase the number of trees (increases pollution removal).
- Sustain existing tree cover in particular large healthy trees (maintains pollution removal levels).
- Maximize use of low VOC emitting trees (reduces ozone and particle formation, increase carbon sink).
- Use long-lived trees (reduces long-term pollutant emissions from planting and removal).
- Use low maintenance trees (reduces pollutants emissions from maintenance activities).
- Reduce fossil fuel use in maintaining vegetation (reduces pollutant emissions).

(modified after Nowak, USDA Forest Service)
Synopsis: Plants in Cities

- Plant trees in energy conserving locations (reduces pollutant emissions from power plants).
- Plant trees to shade parked cars (reduces vehicular VOC emissions).
- Supply ample water to vegetation (enhances pollution removal and temperature reduction).
- Plant low VOC emitting trees in polluted areas or heavily populated areas (maximizes tree air quality benefits).
- Avoid pollutant sensitive species (increases tree health).
- Utilize evergreen trees for particulate matter reduction (year-round removal of particles)

(modified after Nowak, USDA Forest Service)
Moreover

Esthetic Value and Meeting Points
Outlook: Greening Mexico City

Let's Green the Cities, Reduce CO2, Fight Global Warming

Not always easy to achieve!