The role of Green Infrastructure on air quality in urban areas

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The European Commission launched the Covenant of Mayors to oblige European cities to establish an Action Plan to reduce their CO₂ emissions by over 20% through activities and practices including the addition of more plants in urban areas and the sustainable management of the green spaces.

Even stronger Focus on Carbon mitigation potential at urban level after COP21 in Paris.
Urban plant physiology: adaptation-mitigation strategies under permanent stress

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Urban Vegetation: ACTIVE and PASSIVE natural AIR FILTERS

Atmospheric Pollutants Mitigation:
- Stomatal uptake (NOx; SO$_2$; O$_3$; CO)
- Capture - dry deposition (PM)

Particulate Matter (PM10; PM2.5)
- Diffused Airborne particles - dimensions lower than 10 $\mu$m and 2.5 $\mu$m
- Highly diffused and dangerous
Assessing *interactions* between air pollutants *uptake* (O₃, NOₓ and PM) by Green Infrastructure and possible *role of BVOCs*

Big cuvette measurements of leaf gas exchange
campaign using eddy covariance technique

Application and validation of models

Laboratory  GIS+Modelling  Field
Laboratory cuvette results

Calfapietra et al. 2016
Laboratory cuvette results

Calfapietra et al. 2016

Stomatal conductance (mol m\(^{-2}\)s\(^{-1}\))

- *P. pinea*
- *Q. ilex*
- *P. x euramericana*

Ozone uptake (Normalized)

Stomatal conductance (mol m\(^{-2}\)s\(^{-1}\))

Calfapietra et al. 2016
Applying **i-Tree** Population Projector in New York

**Annual Pollution Removal**

Peak values: **152.6, 92.8, 57.5** (tons/year)

Morani et al. 2011
Particulate Matter deposition: city of Terni case study

- **Industrial** city: Steel/Chemical factories
  - ThyssenKrupp
- Factories **into urban environment**
- **Morphological** characteristics

**Flat plain valley surrounded by mountains**

PM deposition on leaves *Quercus ilex* (holm oak)

- EU limits for PM10: 50 µg/m³ for maximum 35 days in one year – 2012: 68 overlay recorded
Particulate Matter deposition: city of Terni case study

SEM (scanning electron microscopy) with EDX

Quali-quantitative analysis:
- Effect of *industrial area* (elemental composition)
- Effect of *streets* (quantities)

Sgrigna et al. 2015; 2016
Strong focus on **air quality mitigation capacity** of **urban vegetation** by media (particularly for PM)
The **BVOCs** Case and Ozone: *photochemical air pollution*

why the Mediterranean is a “hot spot” for VOC and photochemical pollution……

….along the coasts
Low BVOC emitting species in *urban environment* are recommended.
**HOW MUCH?**

Specific **VOCs** and **NOx** quantities: Optimal ozone production

Area of the optimal O3 production
Capodimonte Park eddy covariance station, Naples

More than 130 hectare Inside the city of Naples Dominated by Quercus ilex
EDDY COVARIANCE TOWER

- CO₂ / H₂O: Li-COR LI-7200
- Methane: Li-COR LI-7700
- Particulate matter: FAI OPC Multichannel Monitor
- NOₓ: Ecophysicls CLD 88 Yp NOₓ analyzer
- N₂O: N₂O analyzer Thermo 46i
- Ozone: Dasibi 1108 slow analyzer
  Sextant fast ozone analyzer

- PTR-TOF-MS 8000
  Acetaldehyde, benzene, toluene, monoterpenes, isoprene, methanol, many others

- Gill Windmaster Pro Anemometer

- ARG100 Precipitation Sensor
- Apogee Instruments SP-110 Pyranometer Sensor
- Model 278 Barometric Pressure Sensor
- MP103A Temperature and Relative humidity Probe

1M € TOTAL INVESTMENT
Capodimonte Park eddy covariance station, Naples – the structure

Devices connected to CR1000:
- MP103A Temperature and Relative Humidity Probe
- ARG100 Precipitation Sensor
- Apogee Instruments SP-110 Pyranometer Sensor
- Model 278 Barometric Pressure Sensor

Devices connected to CR6 module:
- Dasibi 1108 Ozone Analyzer
- Sextant Fast Ozone Analyzer
- NOx Ecophysics CLD 88 Yp
- Ionom PTR-TOF-MS
Wind distribution for the period March 2015 – April 2016 (panel a). Half hourly cumulative fluxes distances representing the peak (white circles) (panel b), 70% (dark grey circles) and 90% (light grey circles) (panel c) for the period March 2015 – April 2016. Cumulative fluxes distances were calculated using the footprint model of Kljun et al. (2004).

Guidolotti et al. 2017
Diurnal patterns of NEE (blue), GPP (green) and RECO (red) for the summer period (panel a, April-September) and the winter period (panel b, October-March). The solid lines and shaded bands represent the average and standard deviation of the half-hour flux, respectively.

Guidolotti et al. 2017
Eddy Covariance: *Concentrations and fluxes* (March 2015)

Guidolotti et al. 2017
Eddy Covariance:
GHG concentrations and fluxes (summer 2015)

Guidolotti et al. 2017
Eddy Covariance: Fluxes at the end of the summer 2015

Guidolotti et al. 2017
Does the novel fast-GC coupled with PTR-TOF-MS allow a significant advancement in detecting VOC emissions from plants?

Emanuele Pallozzi, Gabriele Guidolotti, Paolo Cicioli, Federico Brilli, Stefan Felix, Carlo Califipietra

Agricultural and Forest Meteorology 216 (2016) 232–240

Contents lists available at ScienceDirect

Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet

Short communication

Agricultural and Forest Meteorology

Does the novel fast-GC coupled with PTR-TOF-MS allow a significant advancement in detecting VOC emissions from plants?

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Integration and communication: *we need a net!*

Need of establishing a net of such innovative urban park sites because of:

- Interest in accounting C sink capacity of urban forests to be accounted in carbon credits strategy
- Interest in understanding interactions between anthropogenic and biogenic compounds in urban environments
- Interest in understanding pollutant mitigation potential by urban forests
Green Infrastructure approach: linking environmental with social aspects in studying and managing urban forests (GreenInUrbs) 2013-2017
Chair: Carlo Calfapietra

35 COST countries
4 Neighbour countries
2 non-COST countries
FAO
About 200 people involved so far
GreenInUrbs structure and responsible people

- **Chair**: Carlo Calfapietra, IT; **Vice-Chair**: David Pearlmutter, IL

- **WG1** *Environmental services* of GI and UF and implications of climate change (R. Samson, B)

- **WG2** *Social/cultural services* of GI and UF (Liz O’ Brien, UK)

- **WG3** *Governance* of UF in a GI approach (S. Krajter Ostoic, HR)

- **WG4** Task Force on *Integration and Dissemination* to stakeholders (G. Sanesi, IT)

- **STSM Coordinator**: Rocio Alonso, ES (funded more than 40 STSMs)
OBJECTIVES

- To **collate** recent (qualitative and quantitative) **findings** from national or international programmes about the **ecosystem services** provided by **GI** and **UF**.
- To **compare** different approaches and conditions (climatic, socio-cultural, economic and urban planning) in the countries involved, in order to **develop** best practice guidelines for GI managers and decision makers to assist in the **maximization of benefits** from GI and UF.
- To **define** environmental and social indicators and thresholds in order to improve the environmental quality of our cities, and consequently the quality of life of European citizens.
- To provide scientific evidence in order to implement those best practice into legislation both at local, national and European level.
- To identify the main priorities and challenges in terms of future research on GI and UF.
Workshops

GREEN INFRASTRUCTURES AND URBAN FORESTS
IN THE URBAN PLANNING:
NEW APPROACHES AND CHALLENGES

18TH-19TH APRIL 2016
CURIA MAXIMA
ULCEI PANOLESIO, TREVISO

CHAIRS AND SPEAKERS
Training Schools

Alnarp (Sweden 2014)
Pieve Tesino (Italy 2015)
Duisburg (Germany 2016)

Focus on practical training

In each school
20 grants 600 € each

Practitioners, Managers, Students, Post-doc
Functional traits of urban trees: air pollution mitigation potential

Rüdiger Grote14, Roeland Samson2, Rocío Alonso3, Jorge Humberto Amorim4, Paloma Cariñena5, Galina Churkina6, Silvano Fares7, Didier Le Thiec8, Úlo Niinemets9, Teis Norgaard Mikkelsen10, Elena Paoletti11, Abhishek Tiwary12, and Carlo Calfapietra13,14

In an increasingly urbanized world, air pollution mitigation is considered one of most important aspects of city planning. Urban trees help to improve air quality by facilitating widespread deposition of particles and through the provision of large surface areas as well as through their influence on wind and air turbulence. However, many of these trees produce wind-dispersed pollen (a known air pollutant) and emit a range of gaseous substances that take part in photochemical reactions – all of which can affect air quality. The degree to which these air-quality impacts are manifested depends on tree properties: that is, their “traits”. We summarize and discuss the current knowledge on how these traits can affect urban air pollution. We also present aggregated traits of some of the most common tree species in Europe, which can be used as a decision-support tool for city planning and for improving air quality models.


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The Urban Forest

Cultivating Green Infrastructure for People and the Environment


Provides the first comprehensive catalog of tree species that is cross-correlated with the ecosystem services they provide in different regions of Europe

» see more benefits
Participation to the sampling campaign on PM deposition on plane trees across Europe

- 17 Countries
- 20 Cities
- 25/08/14 – 15/09/14

Antwerp (BE)  Copenaghen (DK)  Ljubljana (SI)  Timisoara (RO)
Aveiro (PT)  Den Haag (NL)  Malmo (SE)  Vienna (AT)
Belgrade (RS)  Florence (IT)  Nancy (FR)  Warsaw (PL)
Berlin (DE)  Granada (ES)  Naples (IT)  Yerevan (AR)
Bern (CH)  Kavala (GR)  Salzburg (AT)  Zurich (CH)

SIRM
(Saturation isothermal remanent magnetization) + SEM-EDX analysis

Baldacchini et al, 2017, Environmental Science & Technology
Common European Sampling Campaign

SEM-EDX analyses

Baldacchini et al, 2017, Environmental Science & Technology
Applications

SPECIFIND: Choose the Best TREE SPECIES for Your City

Specifind

Fill in the form specifying your interests and start searching for arboreal plants from which you can get more benefits.

Search Species

Tree Height
- Height at Maturity
  - Min
  - Max
  - m

Locality
- Nation
- Locality
- select

Benefits
- Pollutant Removal
  - Overall
  - Specific
  - Overall Rate
  - 0 (select)

- Low VOC Emissions
  - 0 (select)

- Low Allergenicity
  - 0 (select)

- Carbon Storage
  - 0 (select)

- Air Temperature Reduction
  - 0 (select)

Select All

Report
- Estimate Values per Area Unit
- Generate Report per
  - Specie
  - Genus
- Show
  - All

In the report you will get a list of the most used tree species for urban greenery, arranged according to a score (rank) expressing the degree of compliance with chased requirements.

Climatic and site requirements are measured (if you specify the location), the correspondence to the possible required height and the value of the potential environmental benefits of species, weighted according to the specified scale of importance from 0 to 10 (*).

In the report there are reported indicative benefit estimates for single adult plant (or m²), too, if required to display them.
GREEN INFRASTRUCTURE: NATURE BASED SOLUTIONS FOR SUSTAINABLE AND RESILIENT CITIES

4-7 APRIL 2017 ORVIETO, ITALY
PALAZZO DEI CONGRESSI (PIAZZA DEL POPOLO)
WWW.GREENINURBS.COM/FINALCONFERENCE
A new orientation of EU R&I policy under H2020 Horizon 2020 Societal Challenge 5

- From understanding problems to investing in innovation to deliver solutions to societal challenges
- Moving Nature-based Solutions forward to transform challenges into innovation opportunities for sustainability, resilience, growth and jobs in:
  1. Smart and Sustainable Cities
  2. Territorial Resilience
  3. Resilient Cultural Landscapes
Sessions (Final Conference)

- Implications of GI on air quality
- GI for water and soil management and remediation
- GI for climate regulation and climate change resilience
- Biodiversity and ecological implications of GI
- Health focused GI - enabling healthy and active lives
- Engaging communities and partners to participate in the co-production of GI
- New governance and funding models for GI
- Science-policy implications of GI
- Economic impact of GI for resilient and sustainable cities
- GI in future urban planning
- Assessing and mapping Ecosystem Services generated by urban GI
- Sustainable management of GI

Scientific Committee
Carlo Calfapietra
David Pearlmutter
Roeland Samson
Liz O’Brien
Silvija Krajter
Giovanni Sanesi
Rocio Alonso
Enrico Brugnoli
G. Scarascia Mugnozza
Final Conference: Venue – Orvieto (Italy)

Palazzo del Governatore
GreenInUrbs Final Conference

- 17 Keynote Speakers
- 186 Oral presentations
- 100 Posters
- More than 400 registered people
- A number of side events
- UFUG Special Issue
- 4 awards for best poster and presentations

(Congrats to Beatriz Castiglione!!)
Thanks to all people of Calfapietra Lab

Chiara Baldacchini, Researcher
Lucia Cherubini, Project manager
Giovanni de Simoni, Technician
Raffaela Esposito, PhD
Olga Gavrichkova, Researcher
Gabriele Guidolotti, Researcher
Corrado Leone, Technician
Michele Mattioni, engineer
Mauro Medori, PhD
Enrica Nestola, PhD
Emanuele Pallozzi, Technologist
Gaspare Perconti, master student
Federica Revoltella, PhD
Andrea Scartazza, Researcher
Gregorio Sgrigna, postdoc
Claudia Tarmati, master student