European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

Final Meeting at PRAGUE (CZ), 5-7 October 2016

New Sensing Technologies for Air Quality Monitoring

Action Start date: 01/07/2012 - Action End date: 15/11/2016 - EXTENSION: 15/11/2016

Summary of activities during COST Action TD1105 related to air phytoremediation performed by Warsaw University of Life Sciences, Poland

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Logo

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ESF provides the COST Office through a European Commission contract

Sources of air pollution in outdoor air of urban areas:

- ✓ Transport:
  - Car
  - Airplanes
  - Trams & trains
- ✓ Buidling heating
- ✓ Power and heating plants
- ✓ Industry

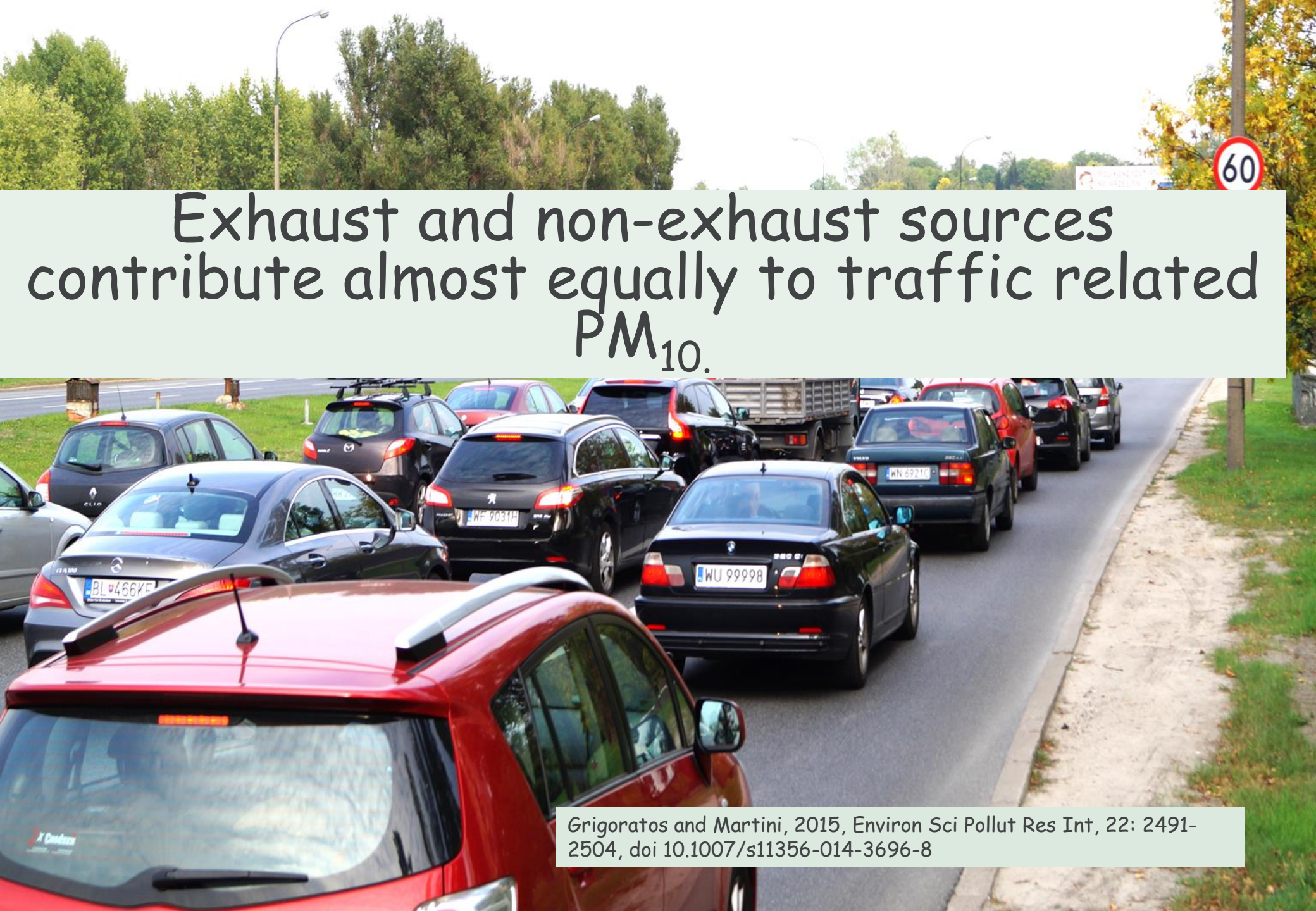
Common air pollutants in urban areas:

- ✓ Particulate matters (10µm, 2.5 and 0.2µm)
- ✓ Gases (NO_2, NO, CO, O_3)
- ✓ Heavy metals (Pb, Cd, Mn, Zn)
- ✓ Polycyclic aromatic hydrocarbons (PAHs)
- ✓ Chlorinated biphenols (PCB)
- ✓ Noble metals (Pt, Pd, Rd)
- ✓ Salinity (de-icing salt, over 90 % NaCl)

www.atmosphere.mpg.de/media/archive/2898.jpg

In 2010, there were about 1 billion cars and trucks on the road worldwide.By 2030, it is expected that this number will reach about 1.7 billion, with the strongest growth taking place in Asia and the Middle East. Motorcycles made up another 0.4 billion vehicles in 2010, and it is estimated that their number will reach 0.9 billion in 2030

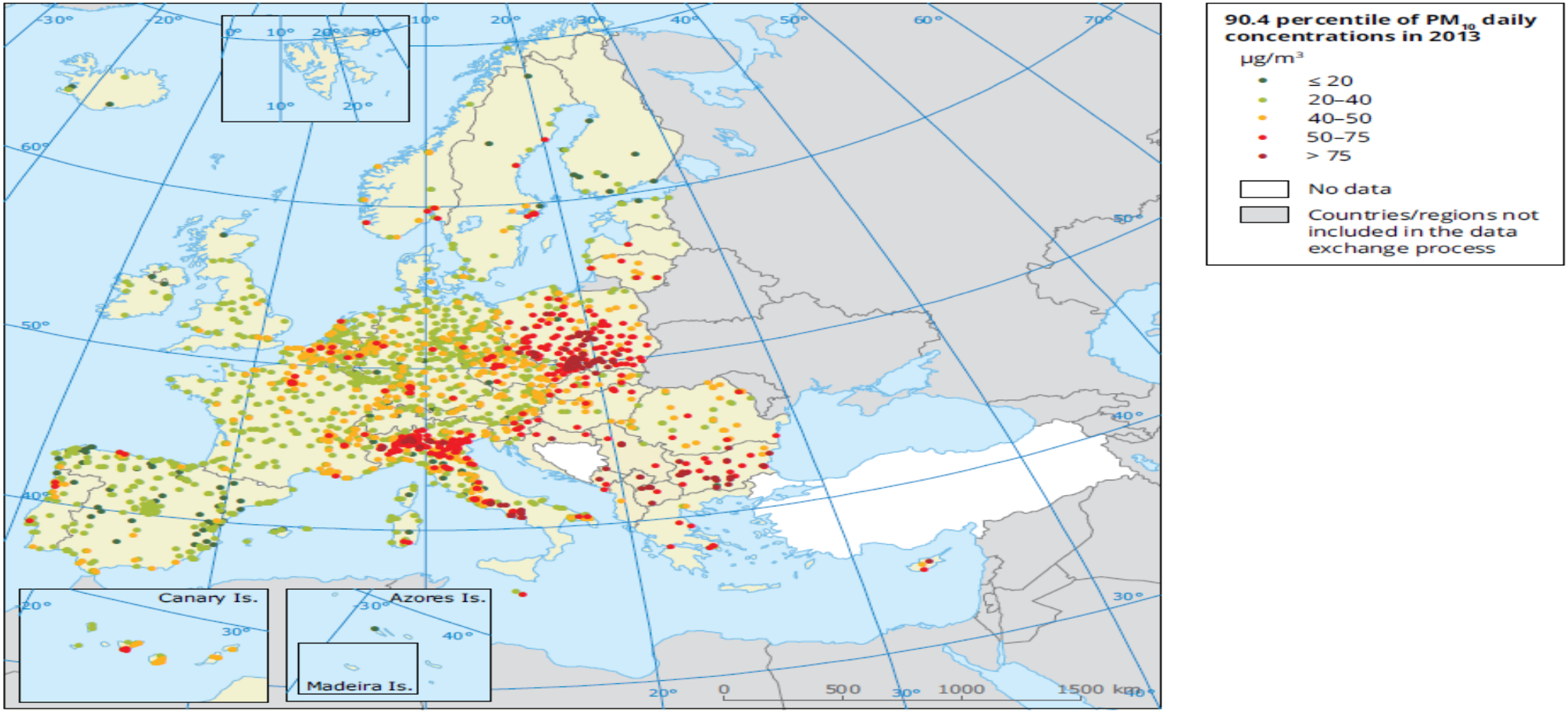
Exhaust and non-exhaust sources contribute almost equally to traffic related PM_{10}.



Grigoratos and Martini, 2015, Environ Sci Pollut Res Int, 22: 2491-2504, doi 10.1007/s11356-014-3696-8

Concentration of PM_{10} in 2013 in Europe

Map 3.1 **Concentrations of PM_{10} in 2013**



Notes: The map shows the 90.4 percentile of the data records in one year, representing the 36th highest value in a complete series. It is related to the PM_{10} daily limit value, allowing 35 exceedances over 1 year of the 50 µg/m³ threshold. The red and dark-red dots indicate stations with exceedances of this daily limit value. Only stations with > 75% of valid data have been included in the map.

Source: Based on Air Quality e-reporting database (EEA, 2015a).

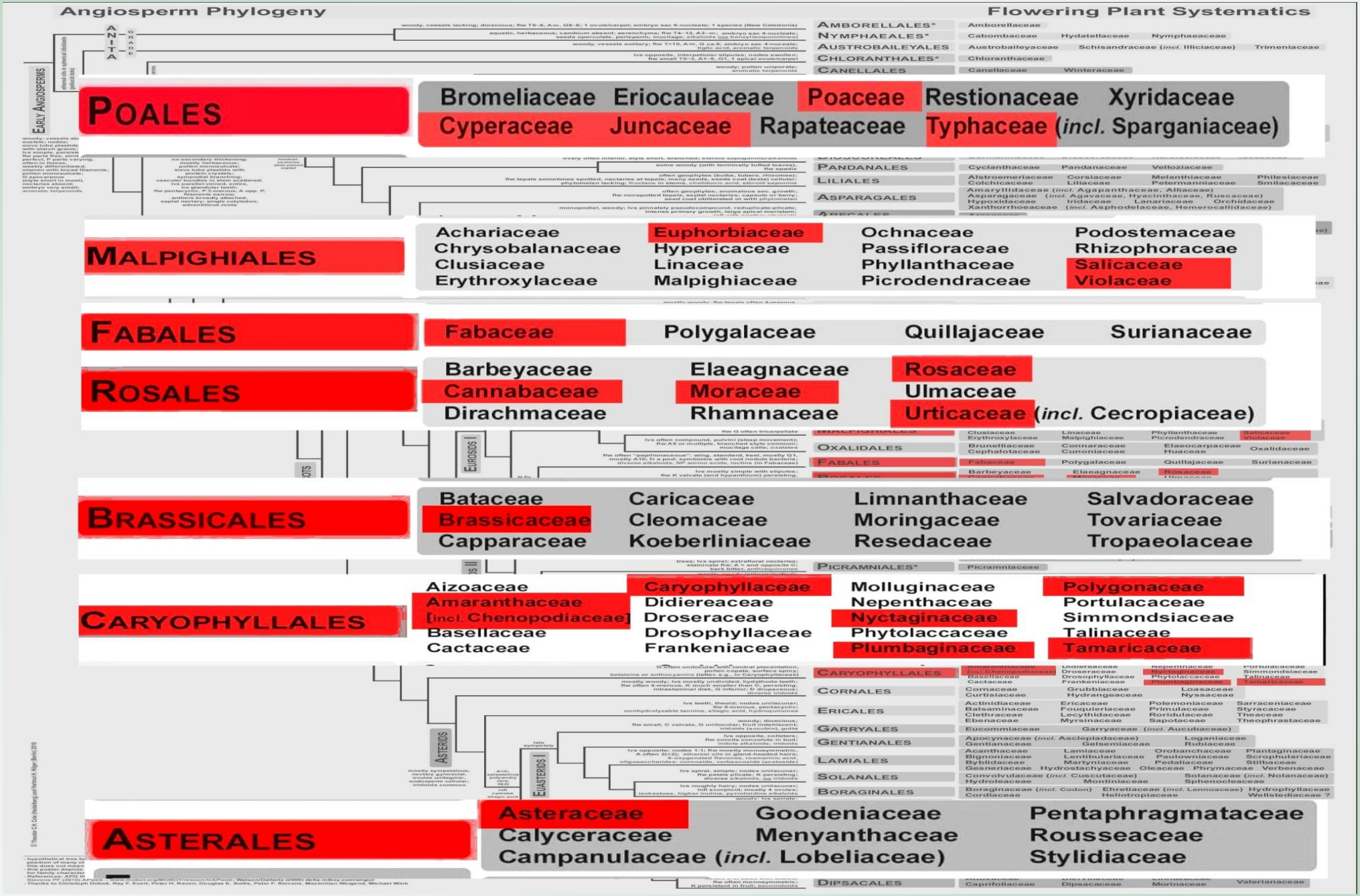
Some species tolerate air pollutants better than others

Photo: S.W. Gawroński

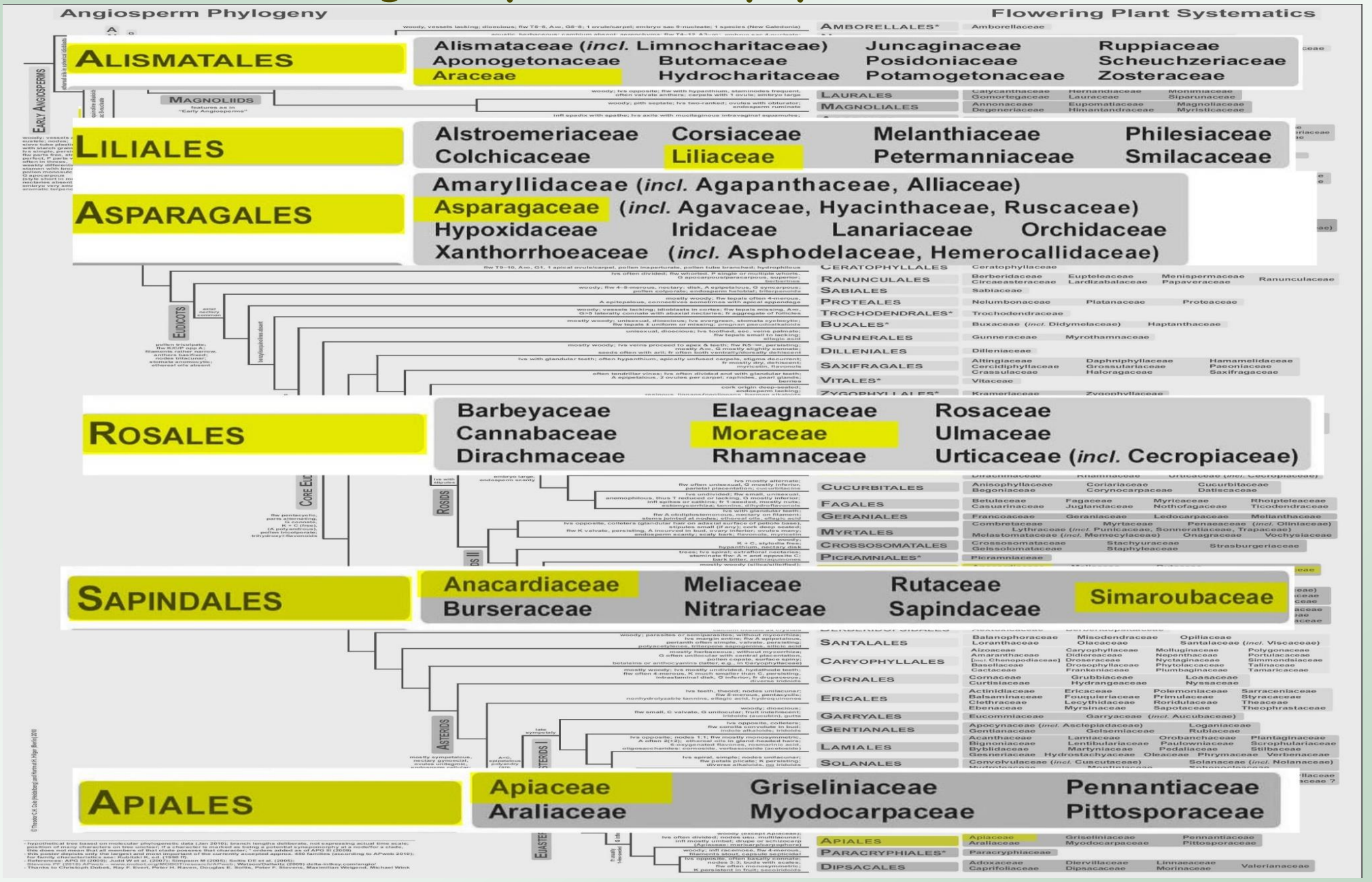
Some plant species tolerate air pollutants better than others

Photo: S.W. Gawroński

Families with species useful in heavy metals phytoremediation



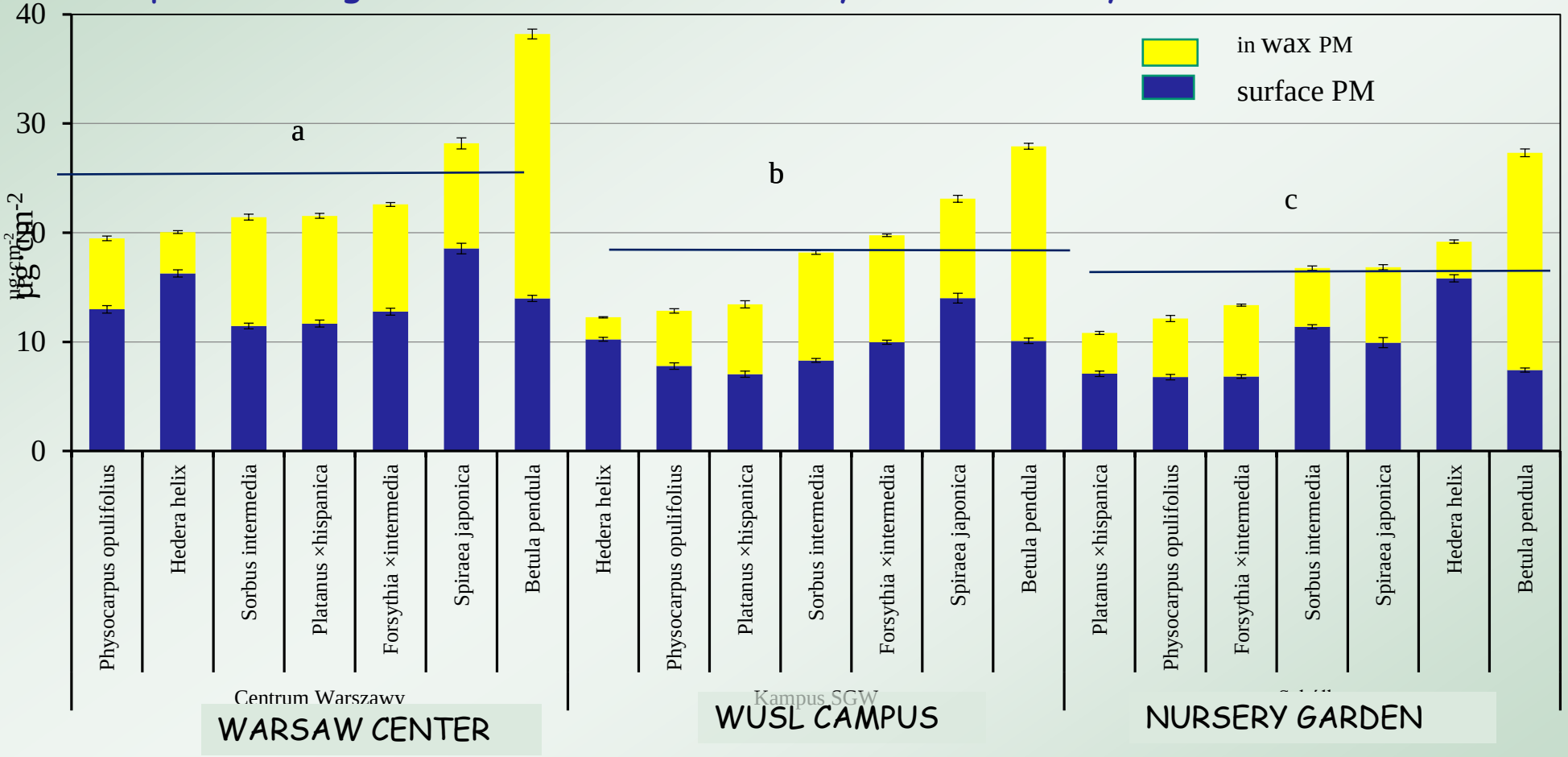
Families with species useful in organic pollutants phytoremediation



Particulate matter and waxes deposited on trees leaf surface (μg cm^{-2})

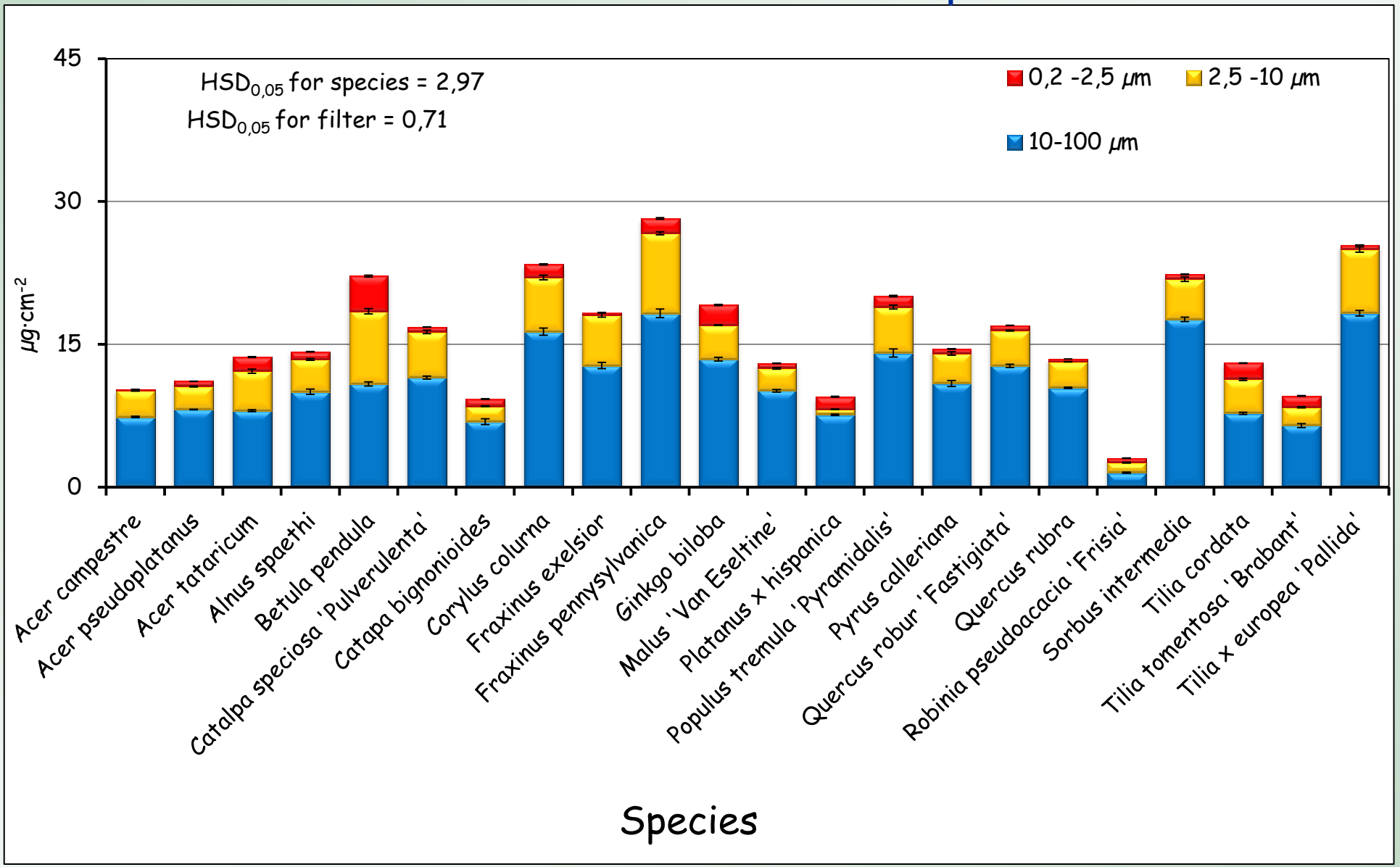
	Species	PM			Waxes
		PM_{11}	$PM_{2,5}$	Σ	
	*Quercus rubra*	12,0	2,8	14,8	110,6
	*Populus simoni*	27,4	9,9	37,3	86,5
	*Betula pendula*	34,3	9,5	43,8	645,7
	*Pyrus calleryana*	33,4	10,0	43,4	157,2
	*Fraxinus excelsior*	23,2	5,6	28,8	94,9
	*Sorbus intermedia*	31,0	11,4	42,4	91,0
	*Cornus alba*	15,5	5,3	20,8	122,3

Total amount of PM accumulated on leaves of 7 woody plant species grown in three sites differing in PM level in ambient air. Data are mean ±SE, n= 12 (2008, 2009 and 2010 x 4 biological replications). Lines over bars represent mean for species at given sites. Different letters over lines refers to significant differences between species for given sites as determined by HSD of Tukey test at α=0,05.



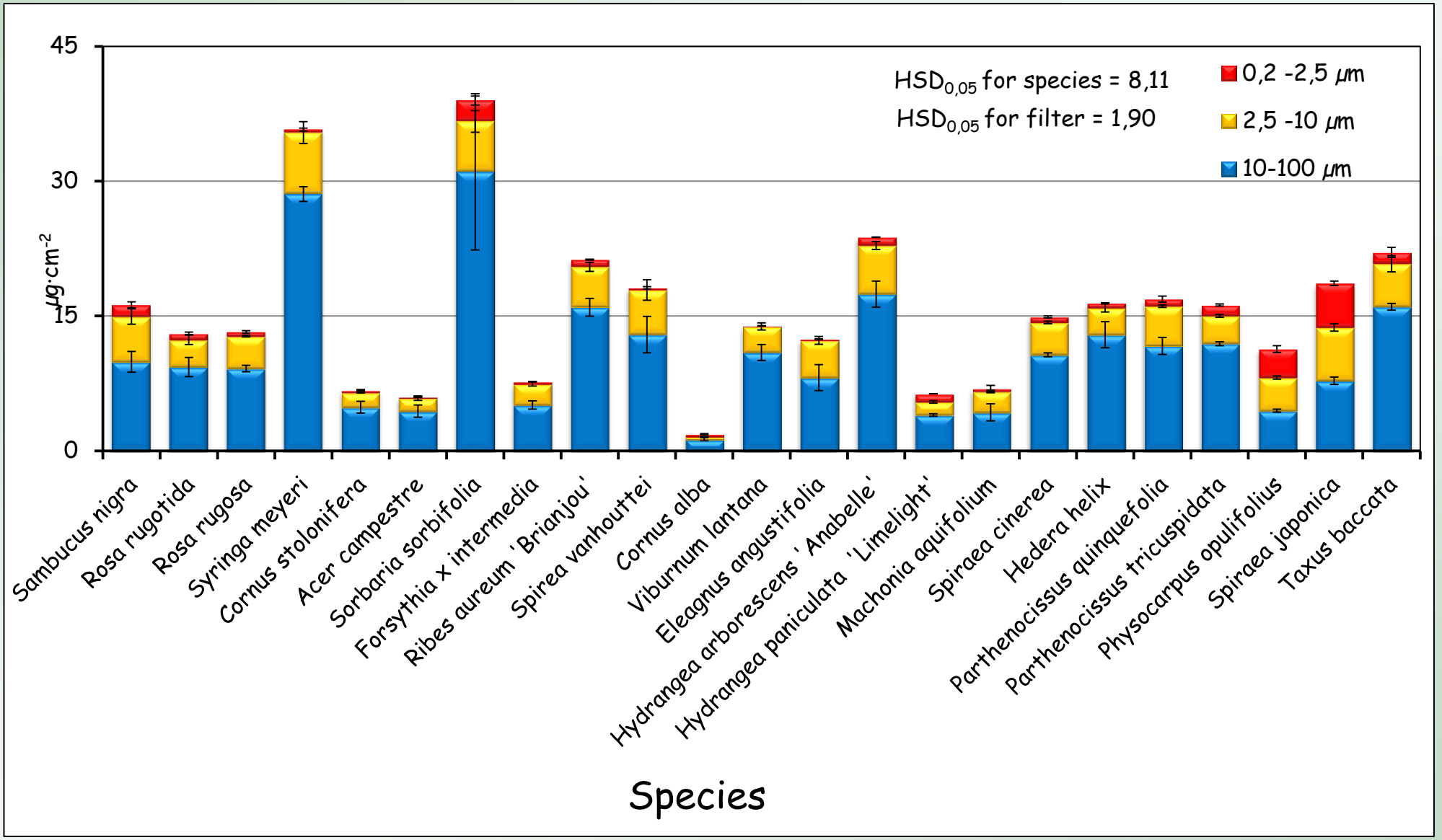
AMOUNT OF PM ACCUMULATED ON LEAVES OF PLANTS GROWN AT CITI CENTER IS SIGNIFICANTLY HIGHER

Amount of particulate matters deposited on leaf surface of 22 tree species



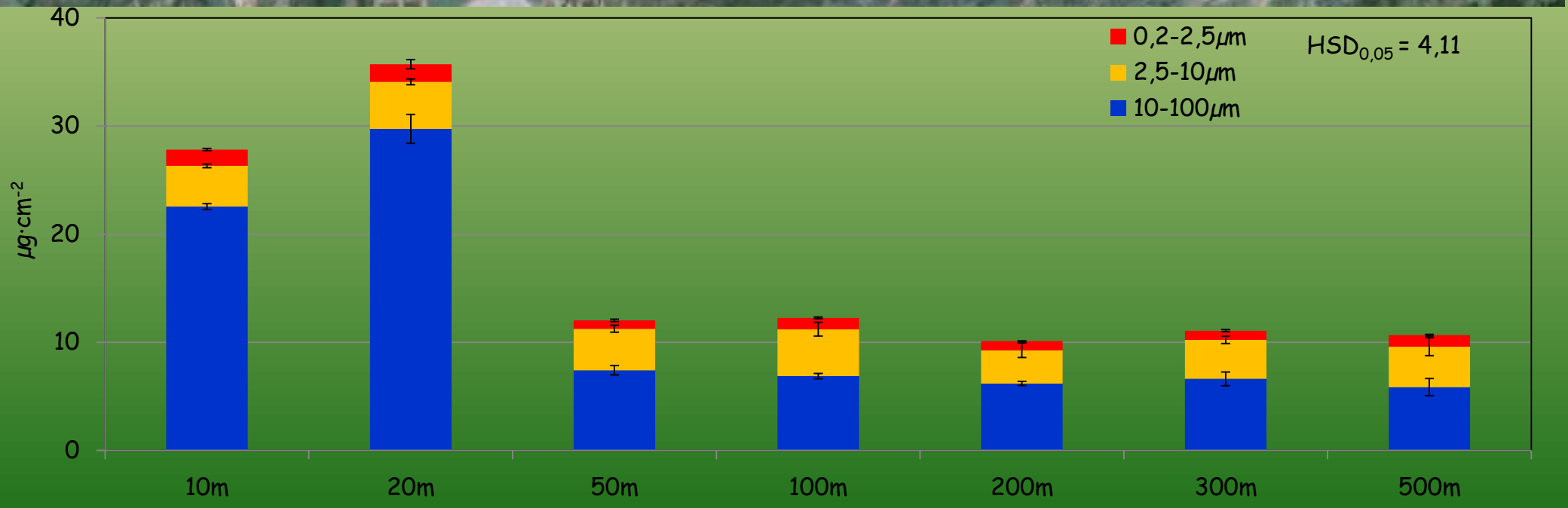
Popek et al., 2012, *Int J Phytoremediat*

Amount of particulate matters deposited on leaf surface and in waxes of 23 shrubs species

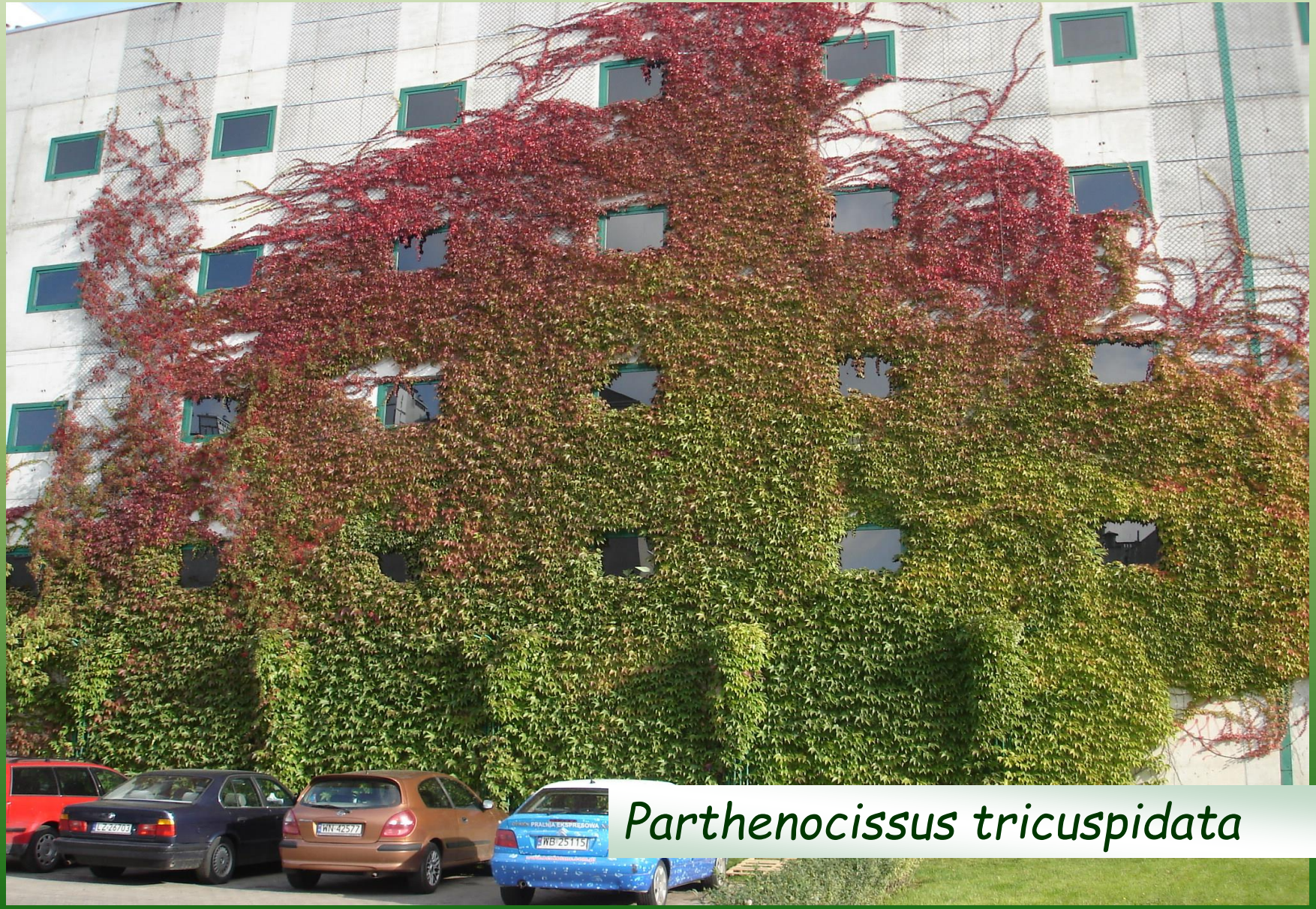


Popek et al., 2012, *Int J Phytoremediat* , Sæbo et al. 2012

Particulate matter content on leaves of linden trees as affected by distance of PM emission, Łazienki Park



Vitaceae:



Parthenocissus tricuspidata

Indoor and outdoor living green walls, Singapore downtown

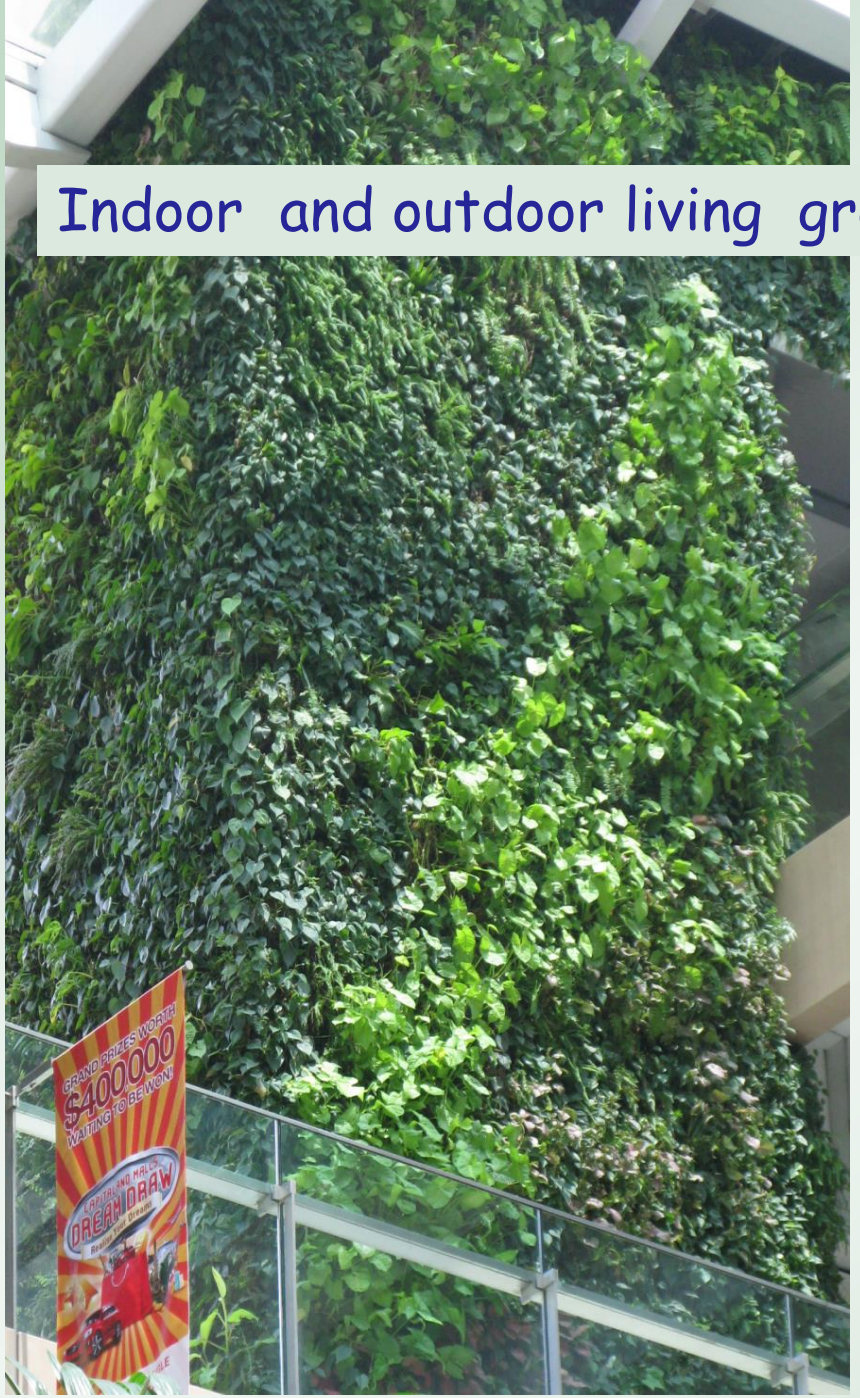


Photo: S.W. Gawroński

Indoor phytoremediation
Botanical biofiltration

Ability to absorb formaldehyde by the spider plant

- during 5 h concentration can be lowered ~20-35 X(from 4-7 to 0,2 μl/l)
- No damage to plant is seen at 10 μl/l, permissible level= = 0,1 μll

Formaldehyde enter plants via stomata and i epidermis

Chlorophytum comosum

Plants also degrade formaldehyde using it as a carbon source for biochemical synthesis of carbohydrates, amino acids and other even more complex molecules. Formaldehyde decomposition occurs with the participation of glutathione-dependent formaldehyde dehydrogenase. Work with *Arabidopsis* and *Nicotiana* on metabolic and genetic modification is advanced (SO_2, NO_2, Cys-synthase activity)

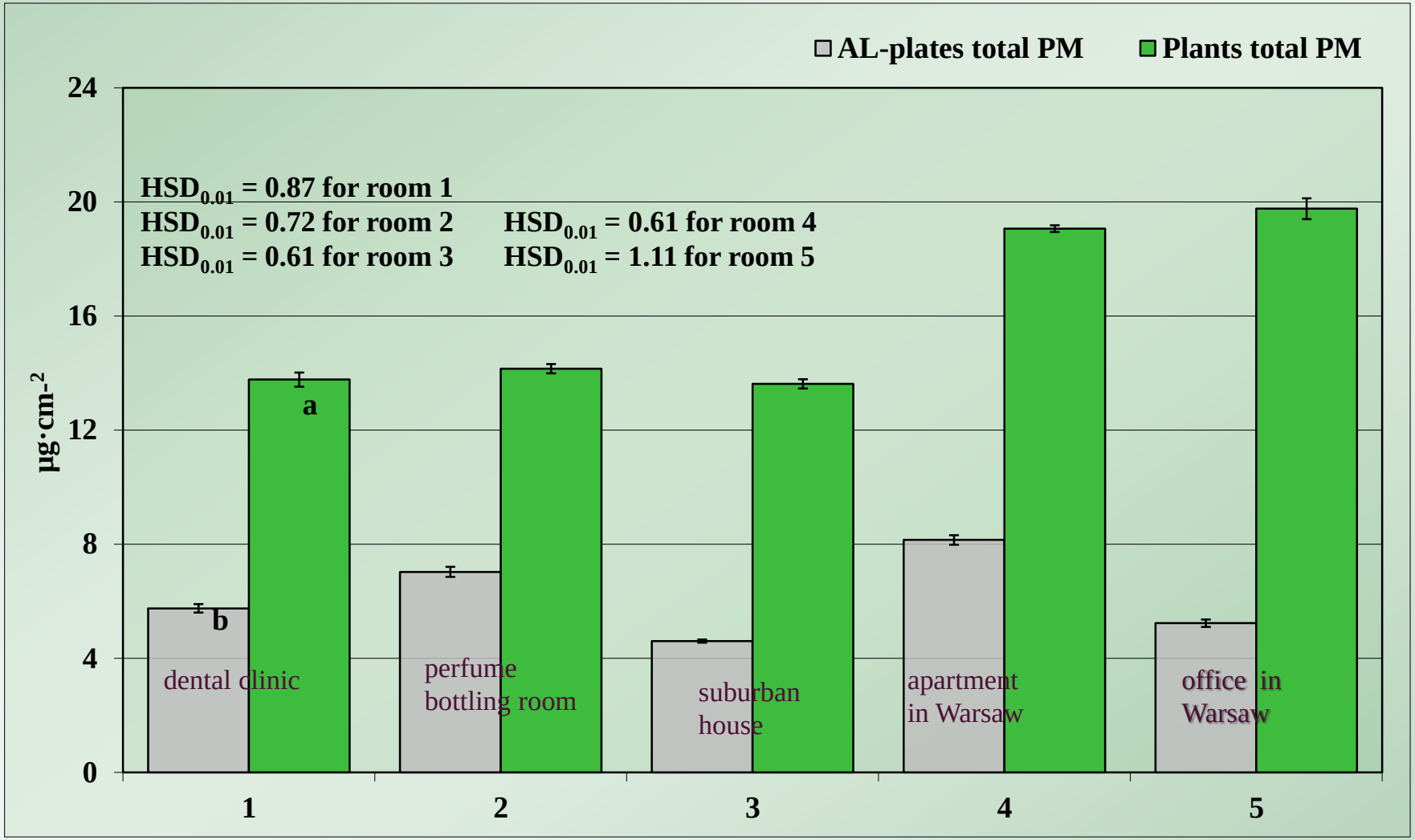
Materials, methods, equipment used (indoor)

Plants of *Chlorophytum comosum* L. and aluminium (AL.) -plates were exposed for 2 months to indoor air in 5 rooms differeing in activities:

- dental clinic
- perfume botling room
- suburb house
- apartment and
- office.

Gawrońska H., Bakera B.. 2015, Air Qual Atmos Health, 8: 265-272

Amount of total PM accumulated on leaves *Chlorophytum comosum* L. and deposited on aluminium plates depends on activities which takes place in particular room



Gawrońska H., Bakera B.. 2015, Air Qual Atmos Health, 8: 265-272

Above reults alowe to conclude:

1. Spider plants (grown indoors accumulate particulate matter of both categories *Chlorophytum comosum* L.) ies and all size fractions, irrespective of their location and the type of activity taking place in the examined room. They therefore phytoremediate PM from indoor air.
2. The amount of PM accumulated on leaves depends on the kind of activity taking place in the particular room.
3. Fine PM, the most harmful to human health, is accumulated to a greater extent as wPM than sPM because it is attached more tightly to leaves and is thereby phytostabilised more effectively. This reduces the risk to human health to a greater extent.
4. Of the three size fractions examined, large PM constitutes the greatest proportion of PM accumulated on plants' leaves.
5. Accumulation of particulate matter on leaves involves factors/forces other than gravitation.

Ability to absorb formaldehyde by the *Ficus benjaminae*

Plants of 70 cm in heith (~1,5 m^2 liści)
Absorbs: 40 μg/h during day
8 μg/h during night

For 16/8 d/n= 704μg

If so, out of the apartment with an area of 40 m^2 and capacity of ~ 100m^3 formaldehyde at a concentration of 0.012 mg/m^3 will be removed completely in about 41 hours

Photo: S.W. Gawroński

Hedera helix
English Ivy

removing **benzene**, **formaldehyde**,
airborne fecal-matter particles

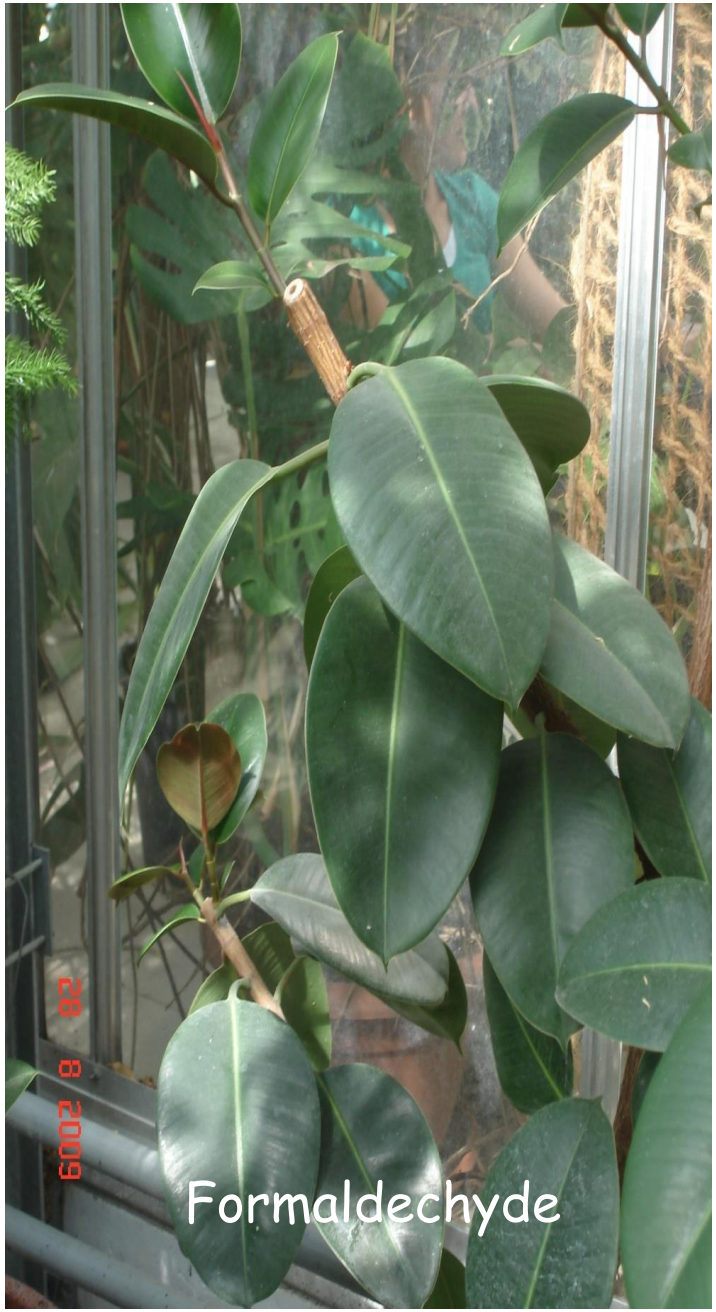
Epipremnum aureum
Golden Pothos, Devils Ivy

top 3 for removing **formaldhyde**
also removing CO

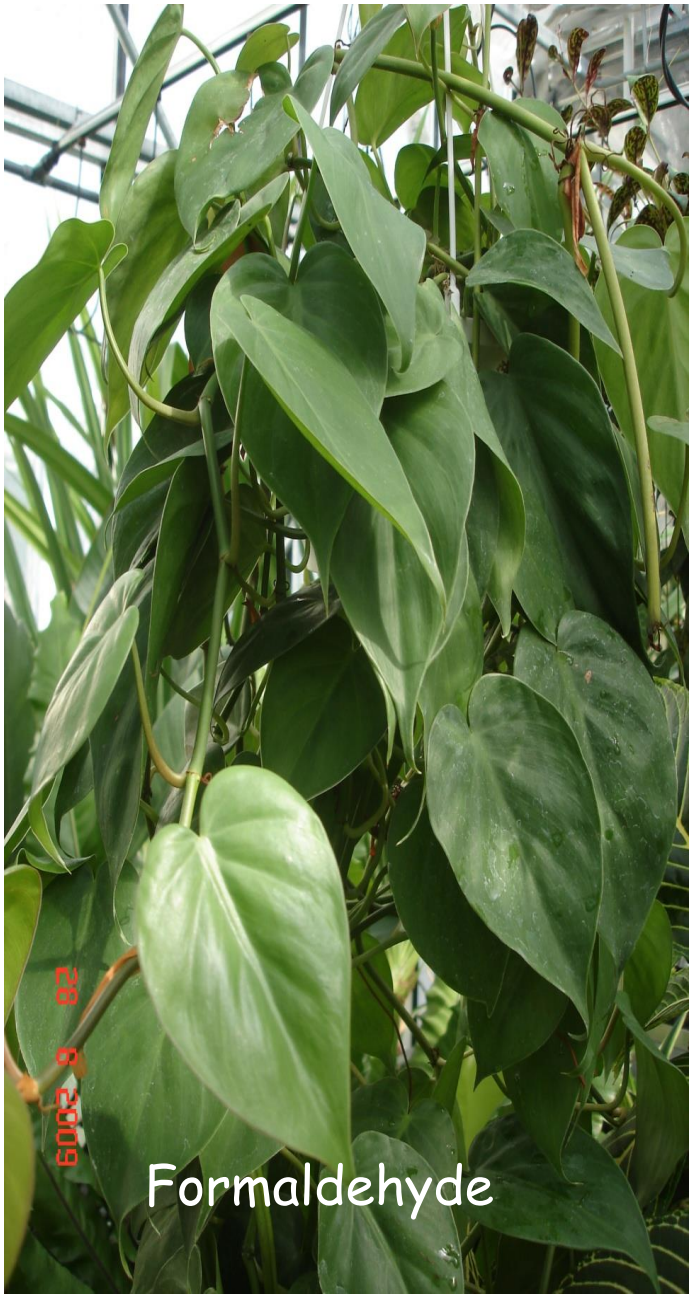
Spathiphyllum Elegant Peace Lily

Removing:

- **VOCs:**
  - **benzene,**
  - **trichloroethylene,**
  - **formaldehyde**
- **alcohols**
- **acetone**
- **toluene and xylene**
- **mold spores**



Ficus sp.

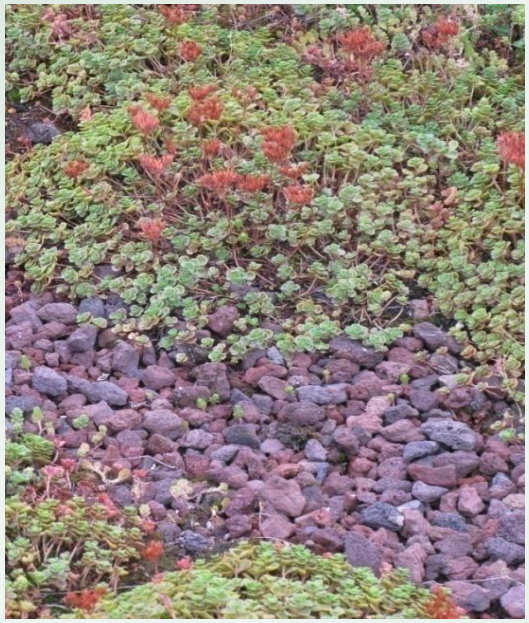


Philodendron

Diffenbachia

Plants type	Day	Night	Remarks
C_3	Stomata open	Stomata closed	Most species grown at ……
C_4	Stomata open	Stomata closed	Many species originated from drought regiones
CAM	Stomata closed	Stomata open	Most species originated from drought regonies
Faculta-tive CAM	Stomata closed when shifted from C_3 or C_4 to CAM	Stomata open when shifted to CAM	Many species after experience of drought tress

Extensive green roofs



Sansewieria trifasciata

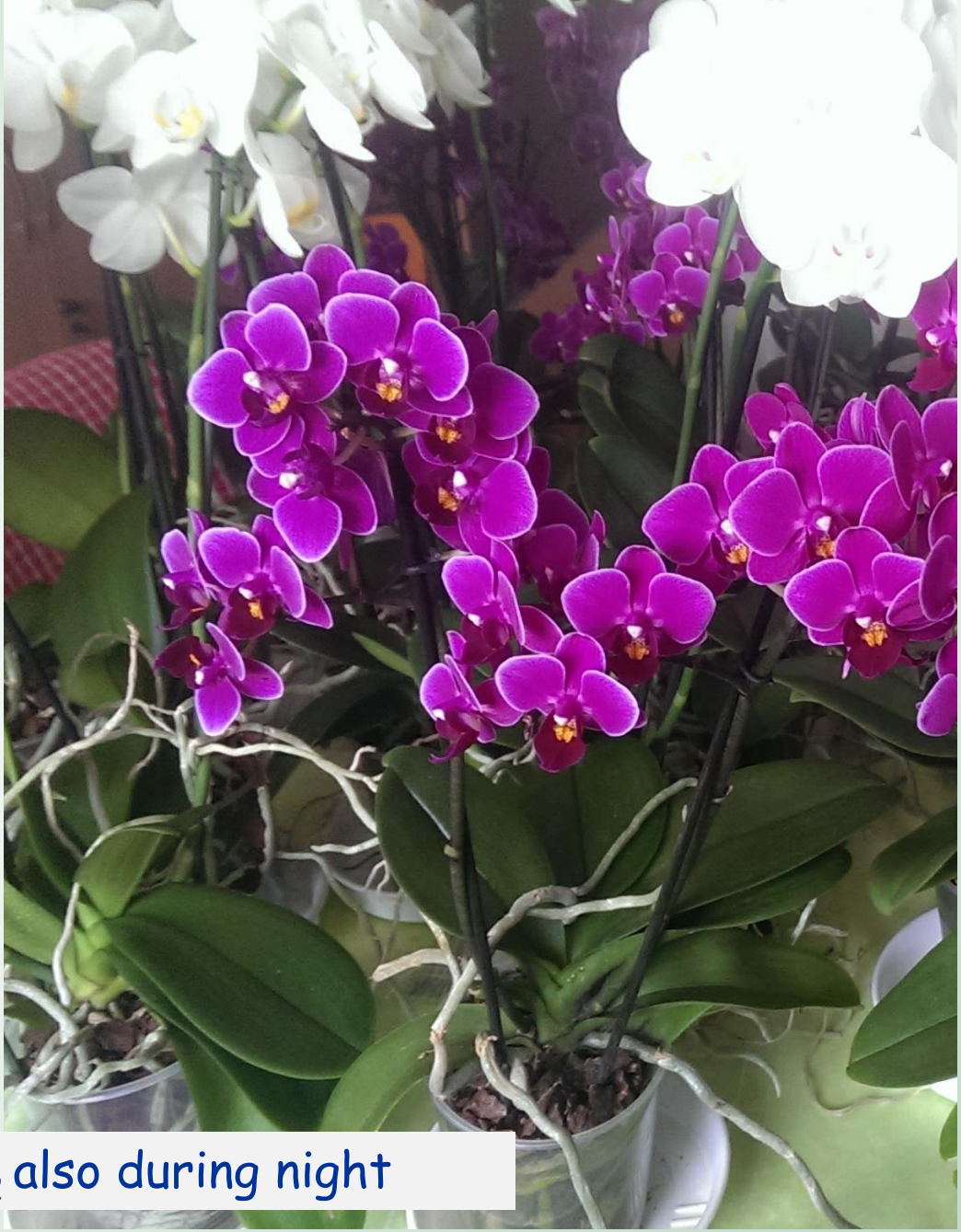
Chamaedorea sefritzi

Zamioculcas zamiifolia

Chlorophytum sp.

Zanthurium sp.

Difenbachia sp.



Formaldechyde, CO_2 also during night

Phalaenopsis sp.

Nephrolepis exaltata var Bostoniensis

Nephrolepis sp. Ferns

NATURAL AIR HUMIDIFIERS

remove formaldahyde,
toluene,
xylene

Remarks:

- Objection against keeping plants in bedrooms due to releasing CO_2 during night not always is true. *CAM*/facultative *CAM* plants uptake CO_2 during night.

- Phytoremediation of indoor air became of high interest and importance especially because at present improving outdoor environment is not an easy task and would last for long.


THANK YOU FOR YOUR ATTENTION
Warsaw University of Life Sciences