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

COST Action TD1105

3rd International Workshop *EuNetAir* on

New Trends and Challenges for Air Quality Control

University of Latvia - Faculty of Geography and Earth Sciences

Riga, Latvia, 26 - 27 March 2015

WHAT CAN BE DONE WHEN POLLUTANTS ARE IN THE AIR

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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

The London Smog (1952)

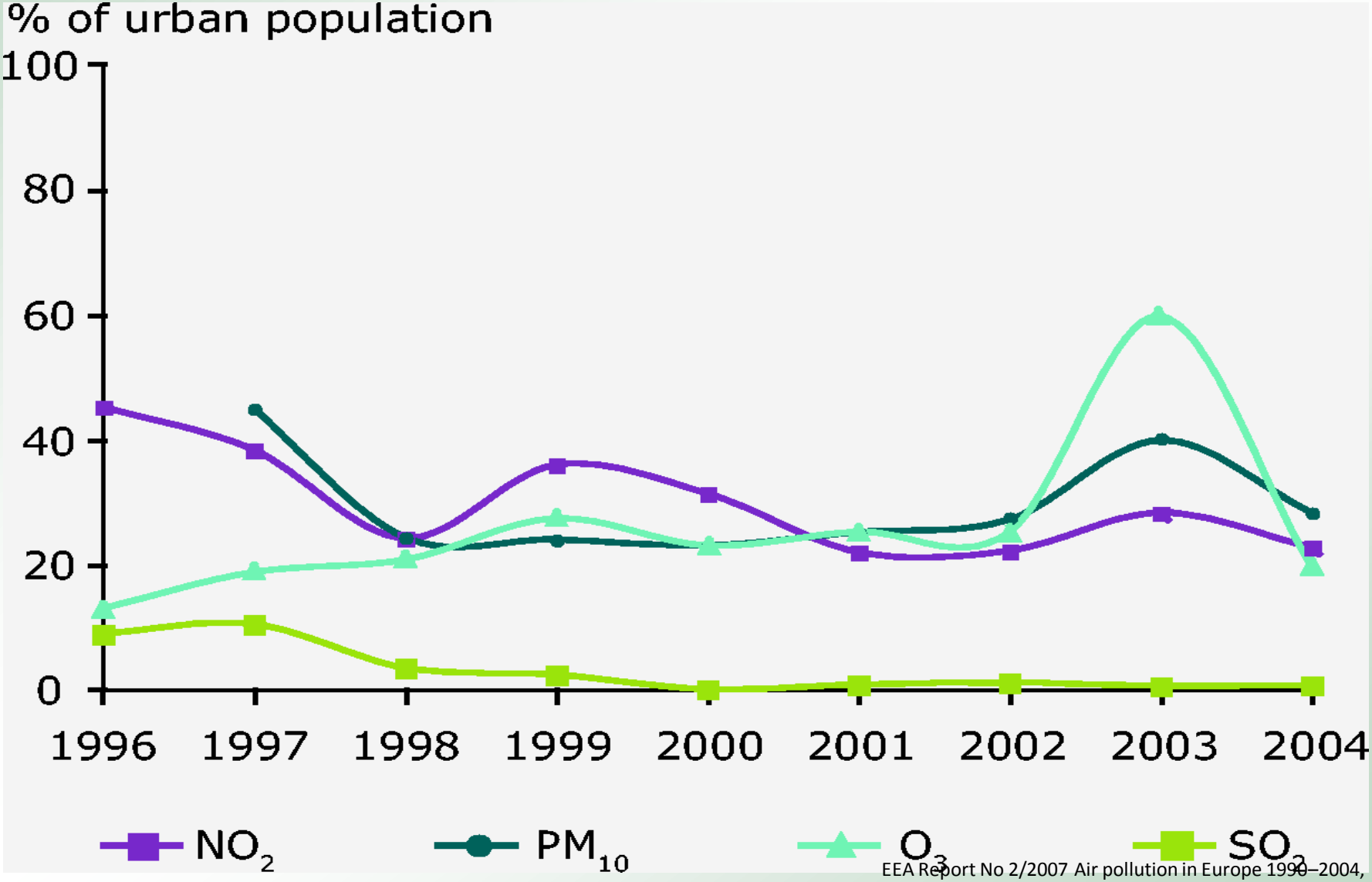
Smog killed 4000 people, another 8000 died in the weeks and month that followed

http://www.npr.org/programs/atc/features/2002/dec/londonfog/bobby_300.jpg

Smog over the city of Los Angeles (caused primarily by O_3)

http://disc.sci.gsfc.nasa.gov/oceancolor/additional/science-focus/locus/amateur_guide_for_air_quality_000.shtml#monitor

Percentage of the urban population potentially exposed to pollutant concentrations over selected limit/target values



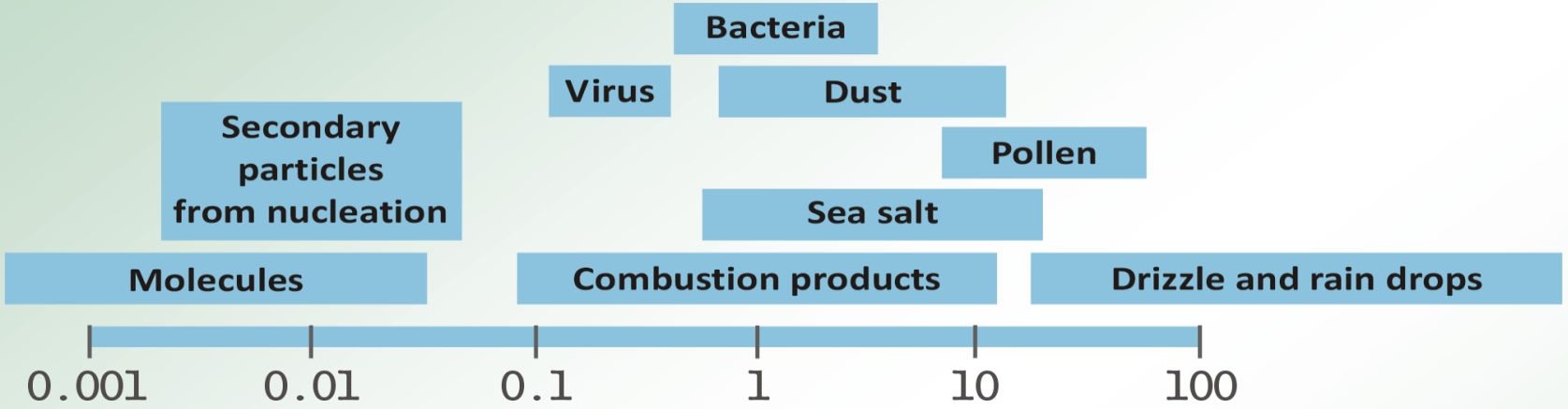
EEA Report No 2/2007 Air pollution in Europe 1990–2004, 28

Some plant species tolerate air pollutants better than others

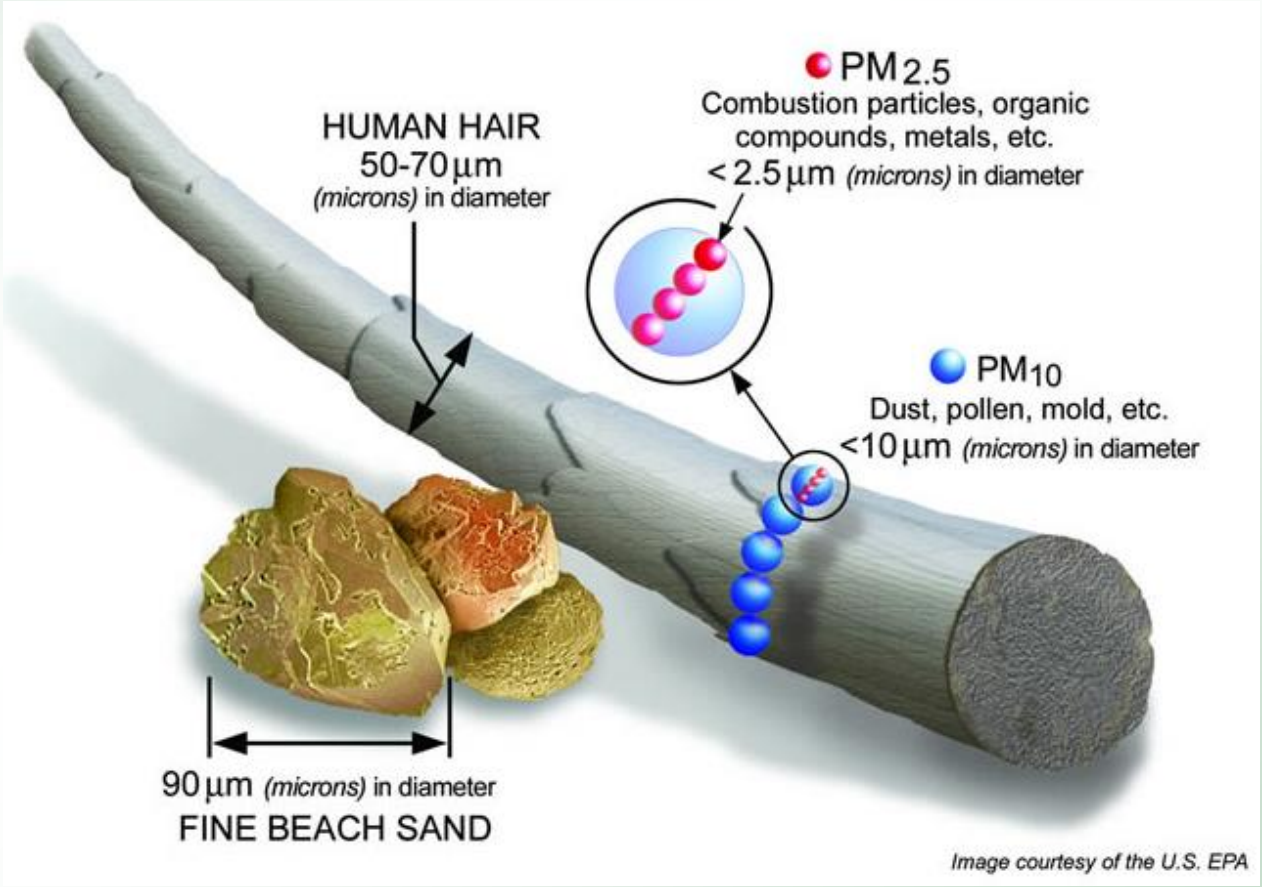
Some plant species tolerate air pollutants better than others


Air pollution -

Particulate matter



10-100 μm
2.5-10 μm
0.2-2.5 μm



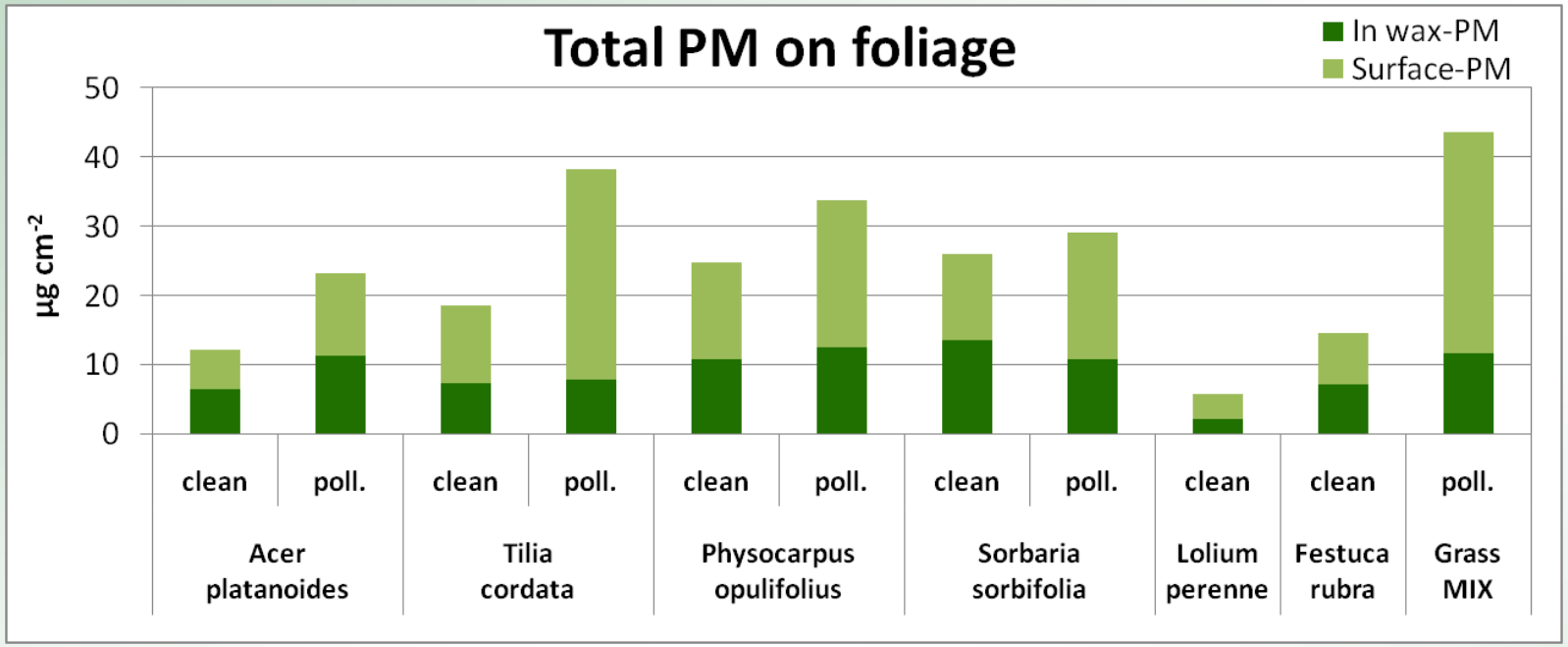
Locations of plants cultivation, differeing in level of air pollution, used for leaves sampling for PAHs content assay

Plant species used in studies:

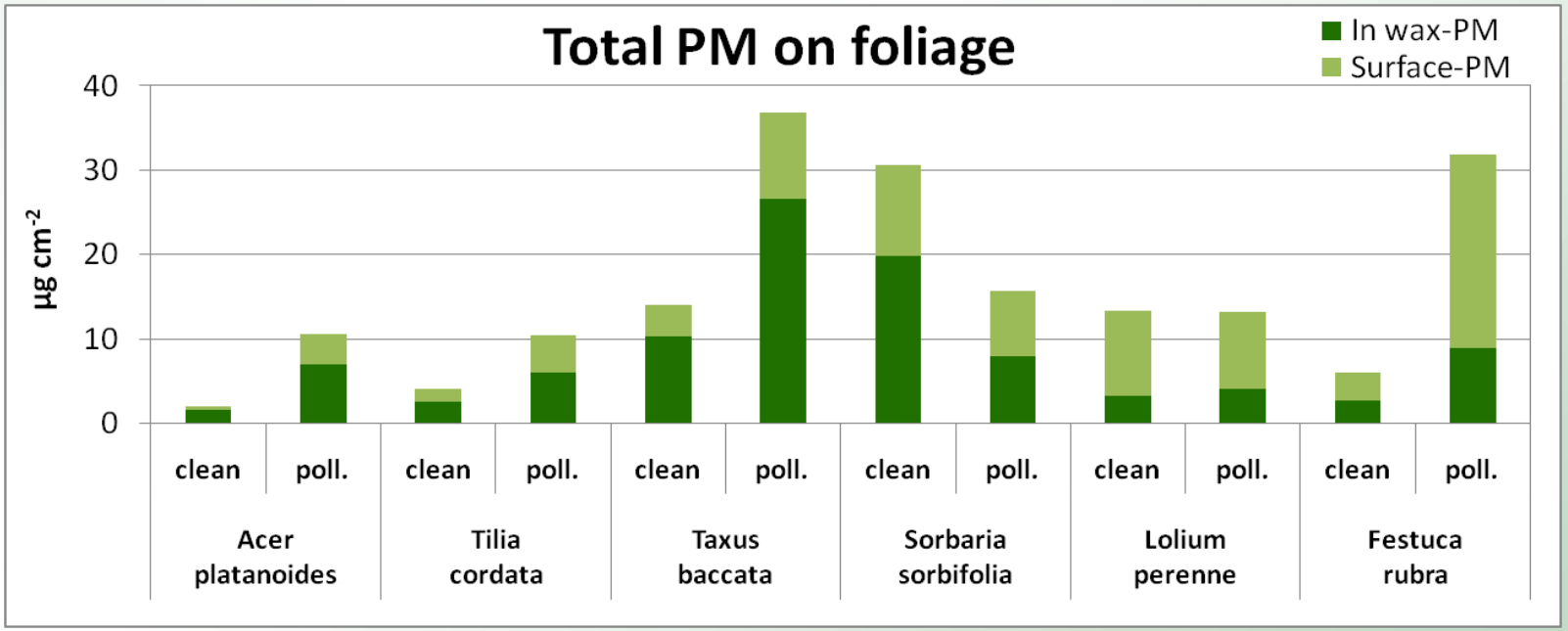
Acer platanoides, Tilia cordata, Physocarpus opulifoius, Sorbaria sorbifolia, Lolium perenne, Festuca rubra (Poland).

In Norway *Physocarpus opulifoius was replaced by Taxus baccata*

POLAND



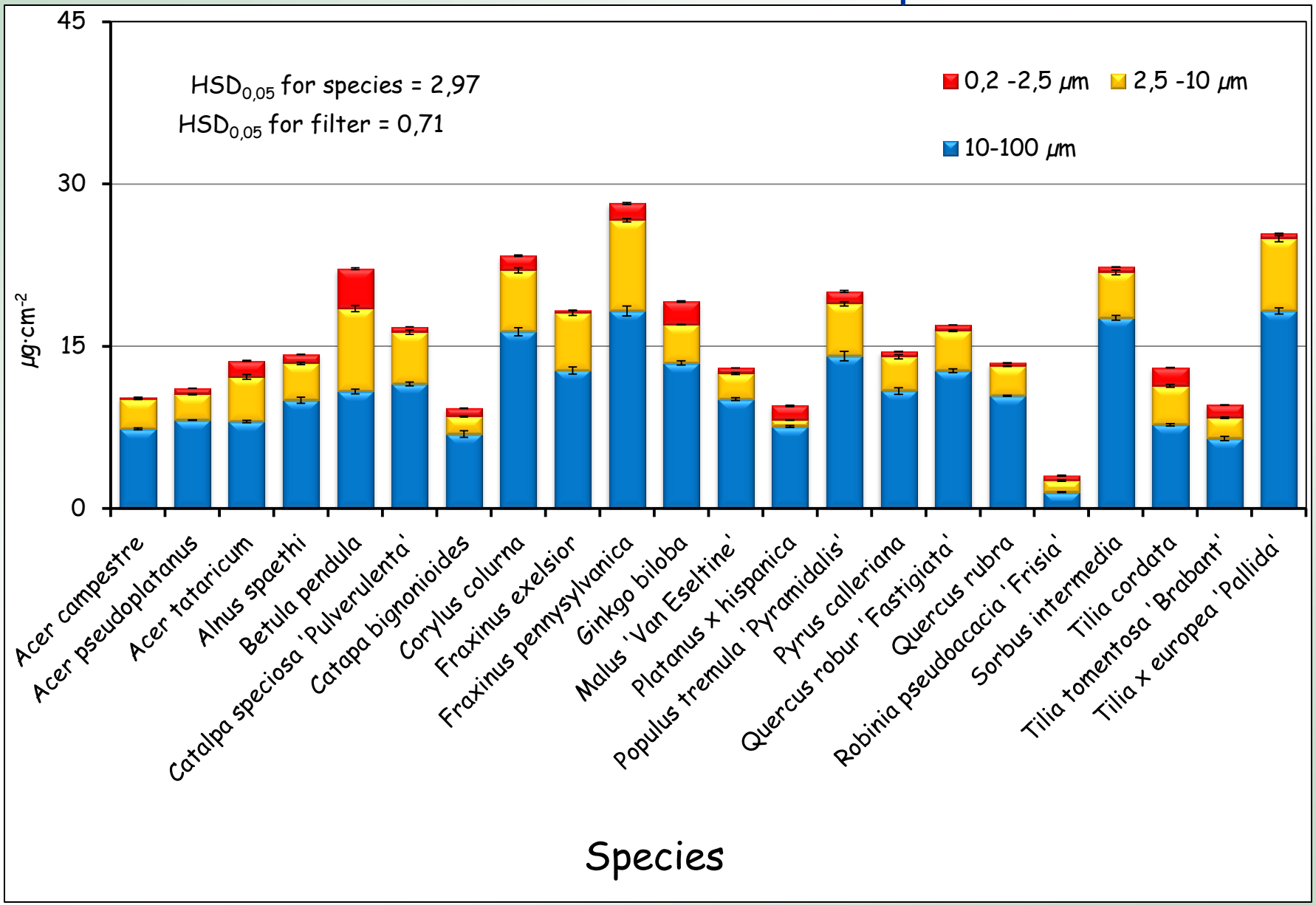
NORWAY



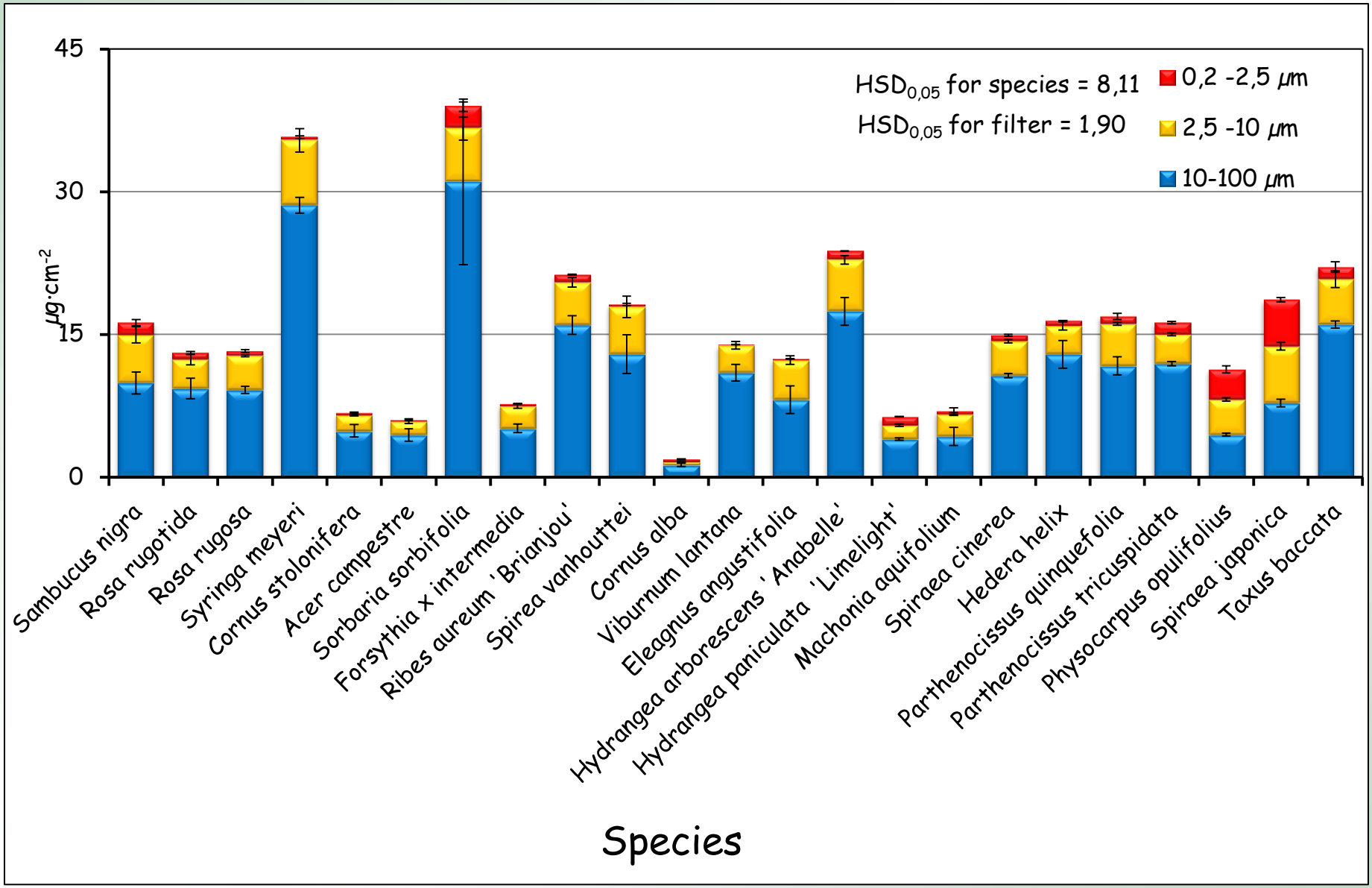
Particulate matter and waxes deposited on trees leaf surface (μg cm^{-2})

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

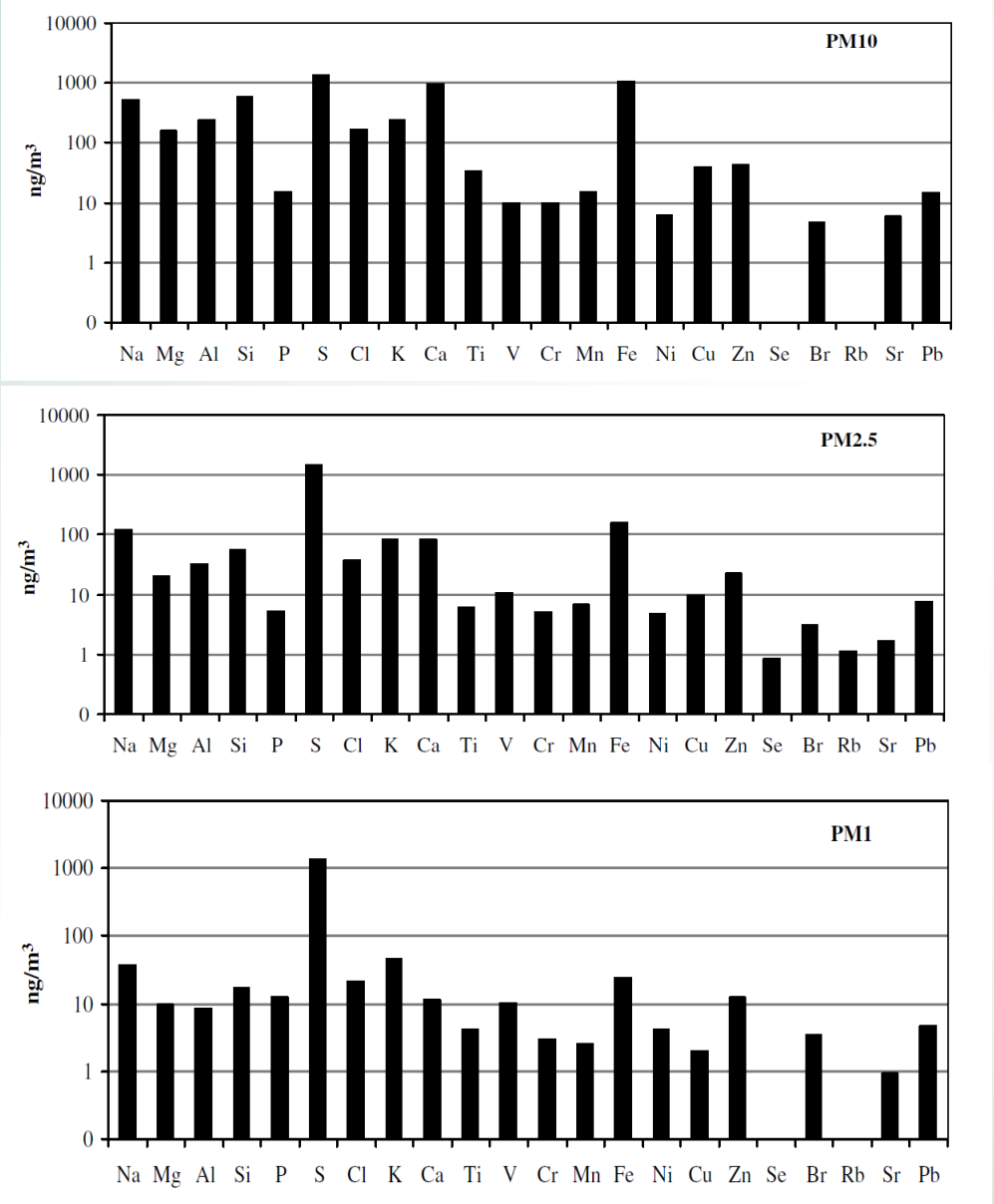
Amount of particulate matters deposited on leaf surface of 22 tree species



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

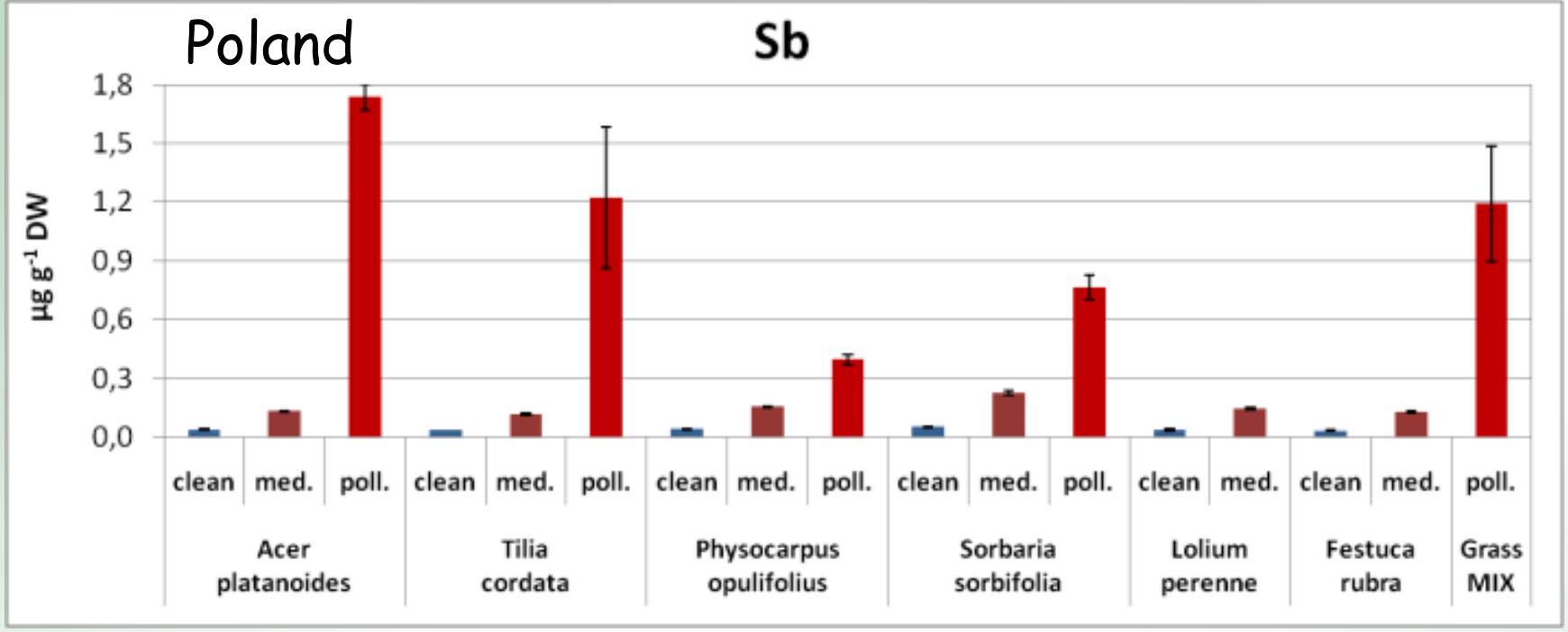


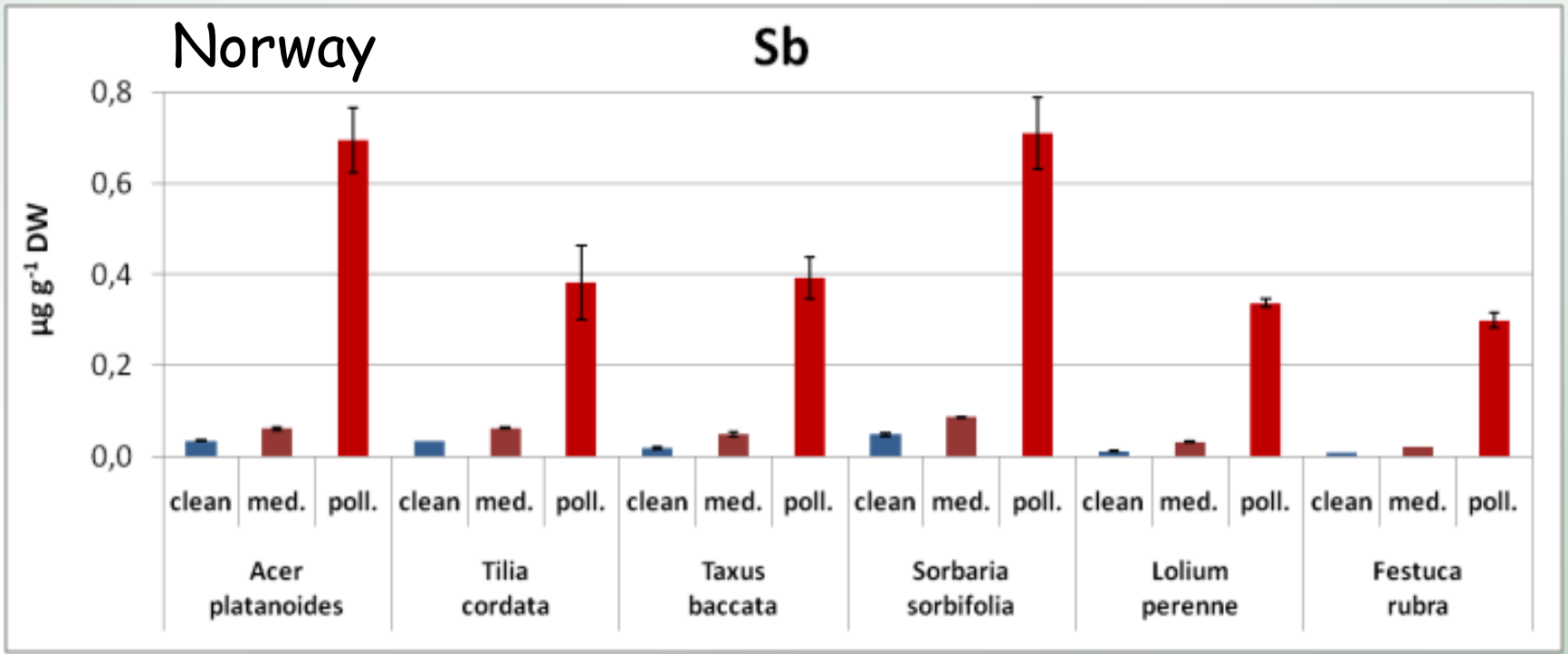

Heavy metals



Elemental composition of PM10, PM2.5, PM1 deduced by PIXE and ED-XRF analysis of PARTISOL filters.

Ariola V, et al. 2006. Elemental characterization of PM10, PM2.5 and PM1 in the town of Genoa (Italy). *Chemosphere* 62(2): 226-232.


Poland
Sb
µg g-1 DW
1,8
1,5
1,2
0,9
0,6
0,3
0,0
clean
med.
poll.
Acer platanoides
Tilia cordata
Physocarpus opulifolius
Sorbaria sorbifolia
Lolium perenne
Festuca rubra
Grass MIX


Norway
Sb
µg g-1 DW
0,8
0,6
0,4
0,2
0,0
clean
med.
poll.
Acer platanoides
Tilia cordata
Taxus baccata
Sorbaria sorbifolia
Lolium perenne
Festuca rubra

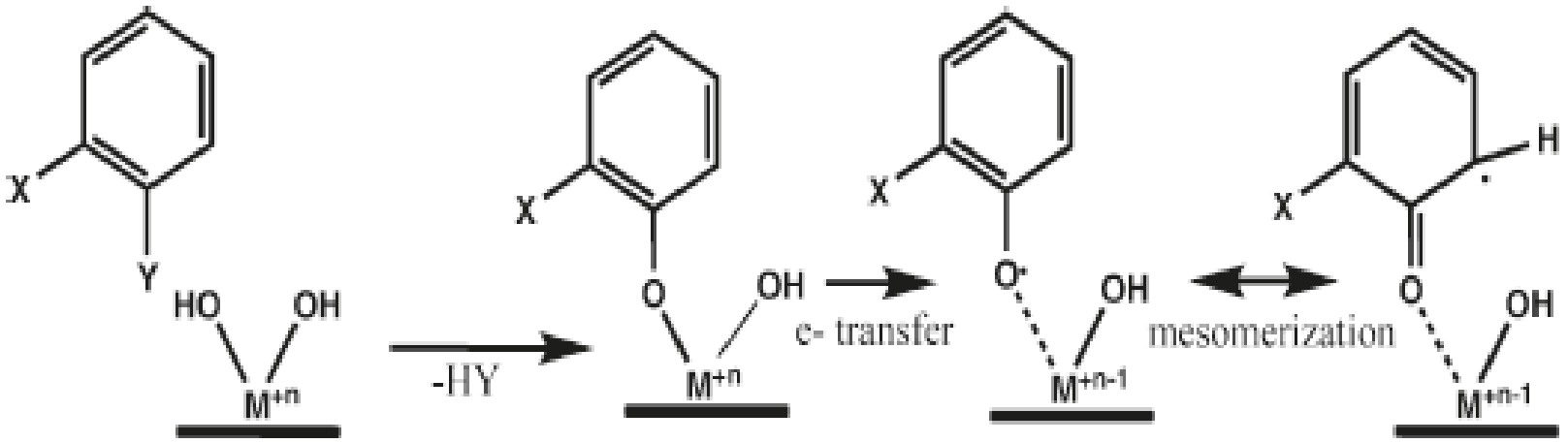


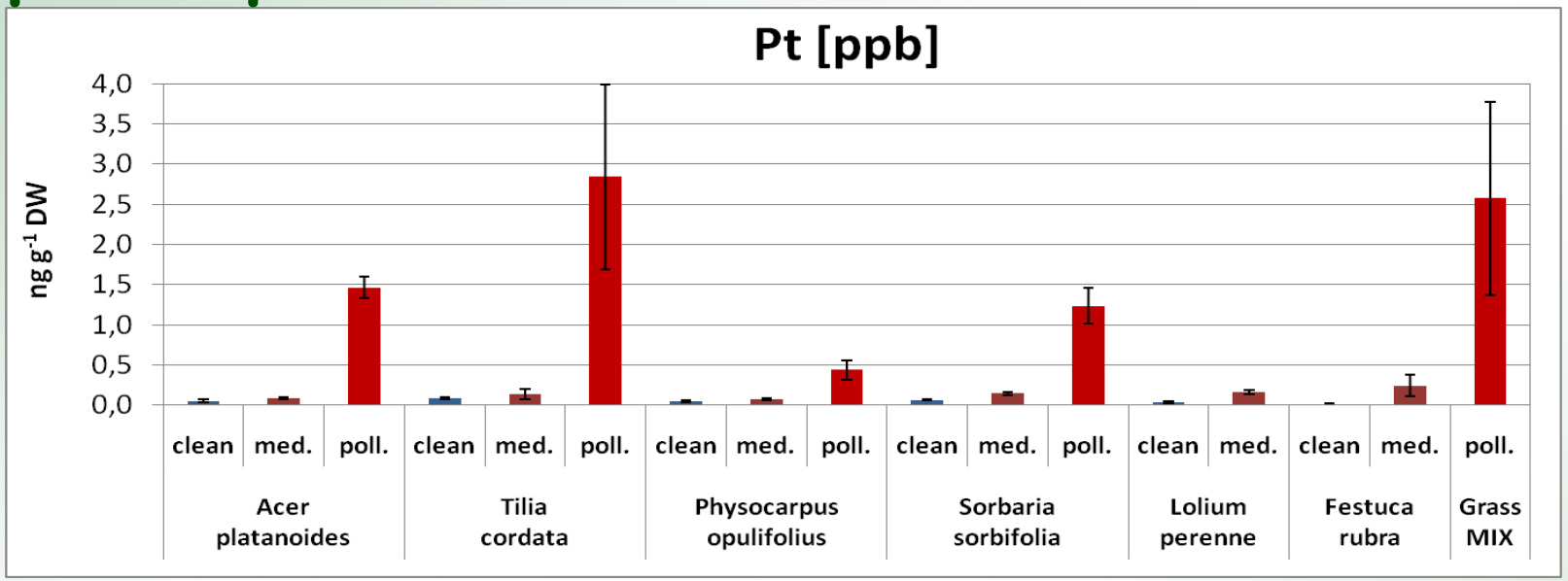
Figure 1. Simplified model of EPFR formation from a substituted aromatic on a metal oxide surface via chemisorption and electron transfer.

Leo A.N.C at al.. Environmental Science and Technology 2011

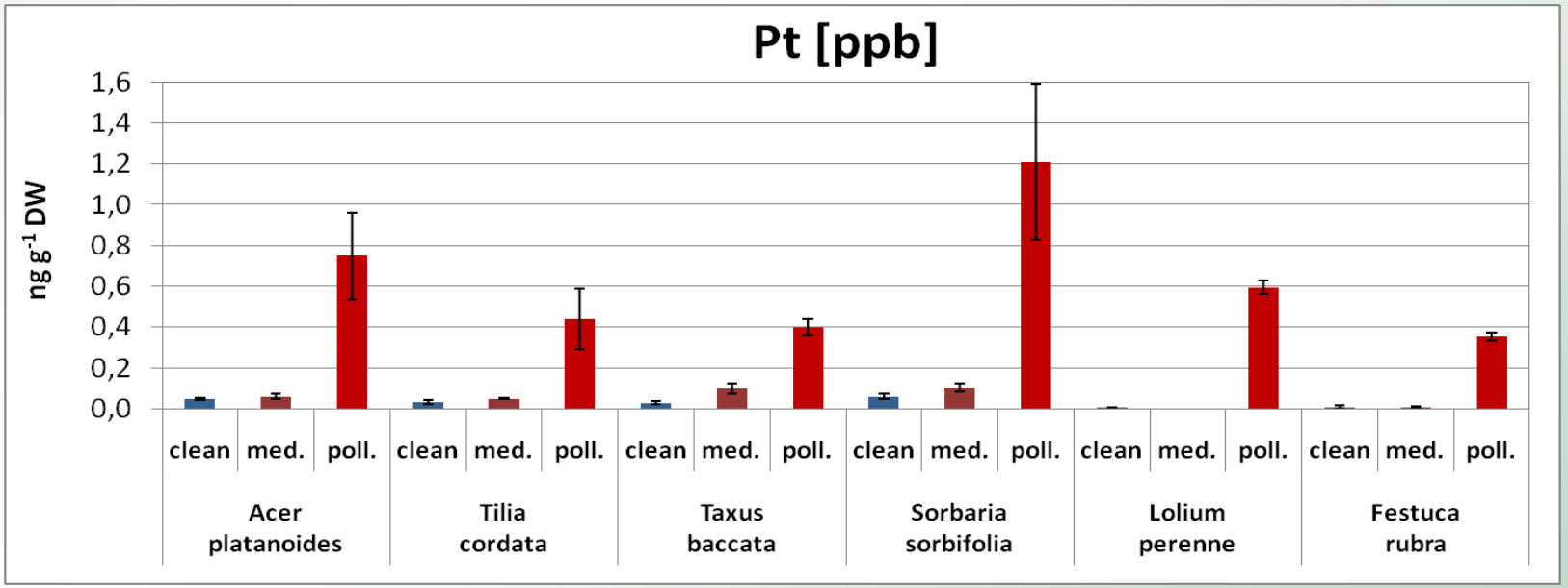

Noble metal: Platinum (Pt)

Concentration of platinum in leaves of six plant species cultivated at three locations

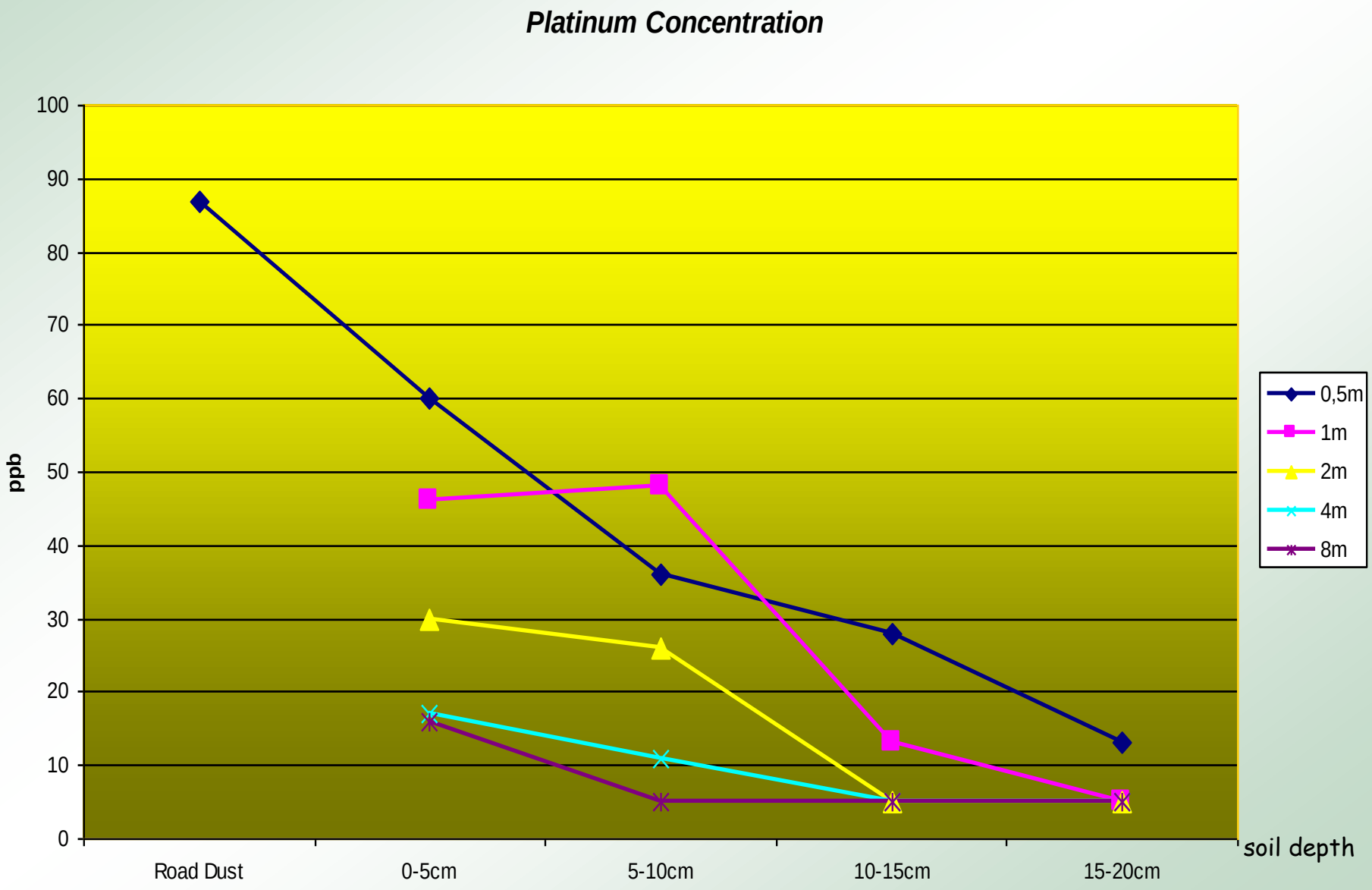
POLAND

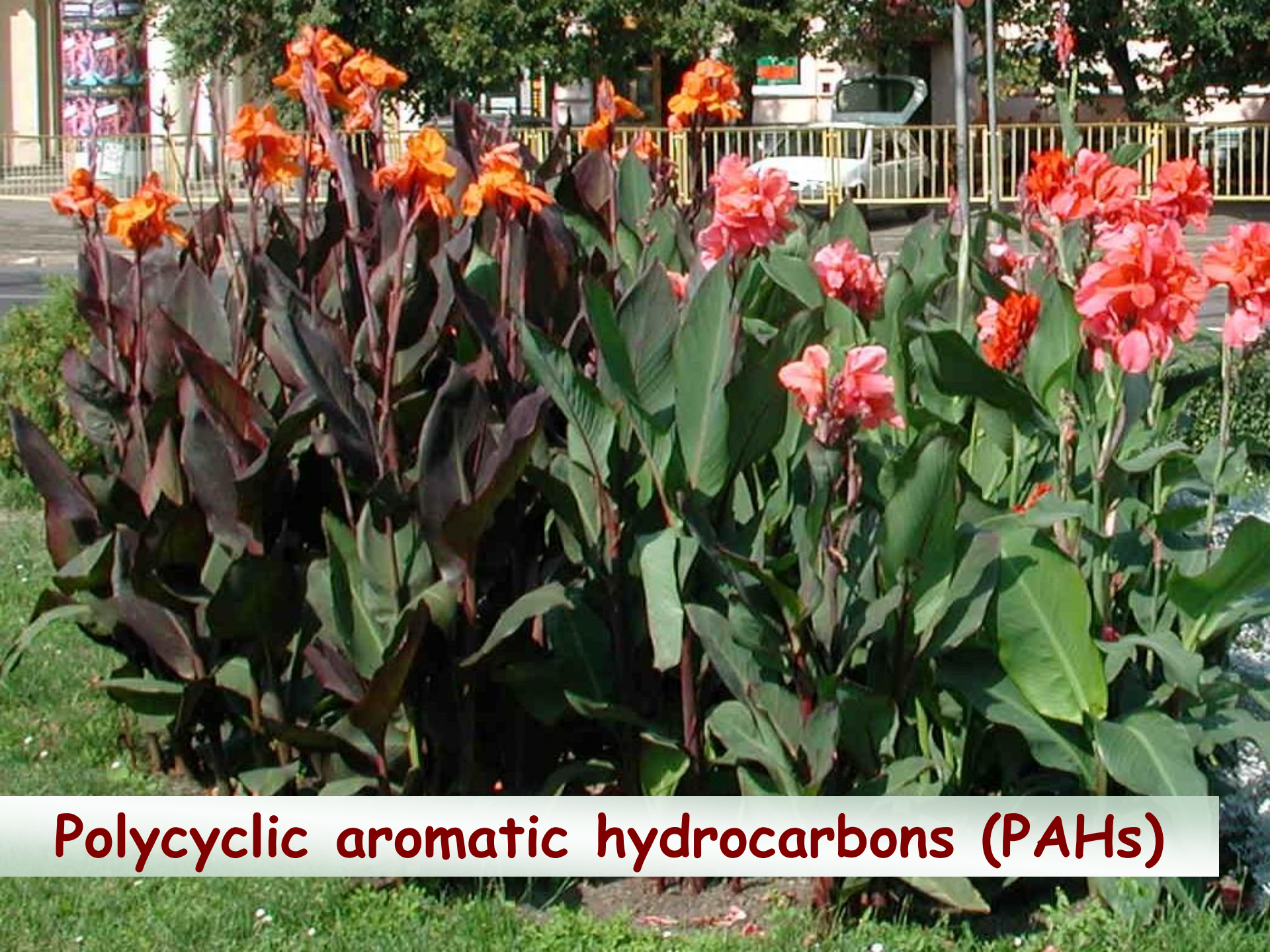


NORWAY



The effect of distance from road edge and soil depth on platinum accumulation



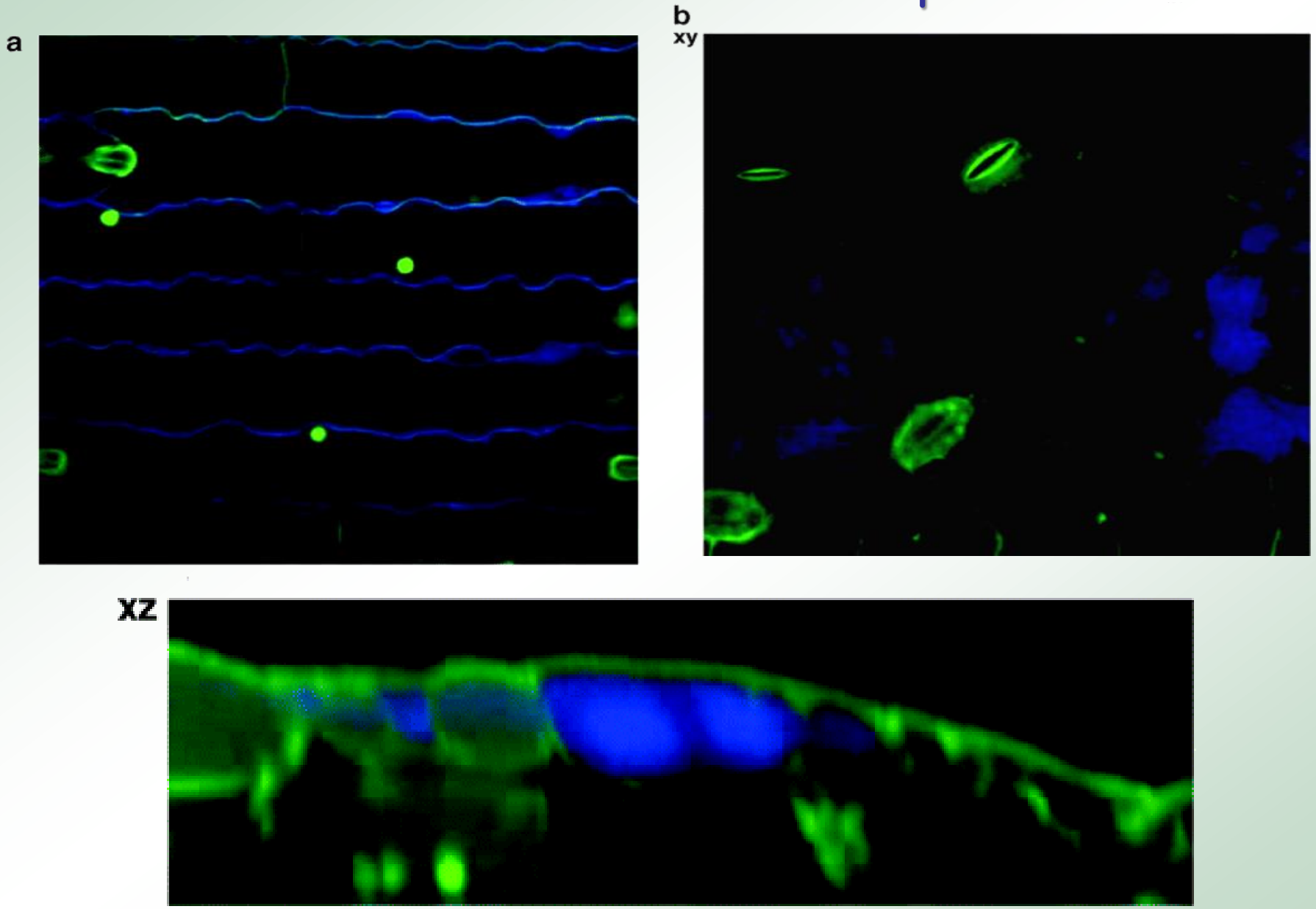


Polycyclic aromatic hydrocarbons (PAHs)

Content of 17 PAHs in leaves of *Canna x generalis* plants assayed after washing with water or in waxes extracted with chloroform (μg kg^{-1} DM.)

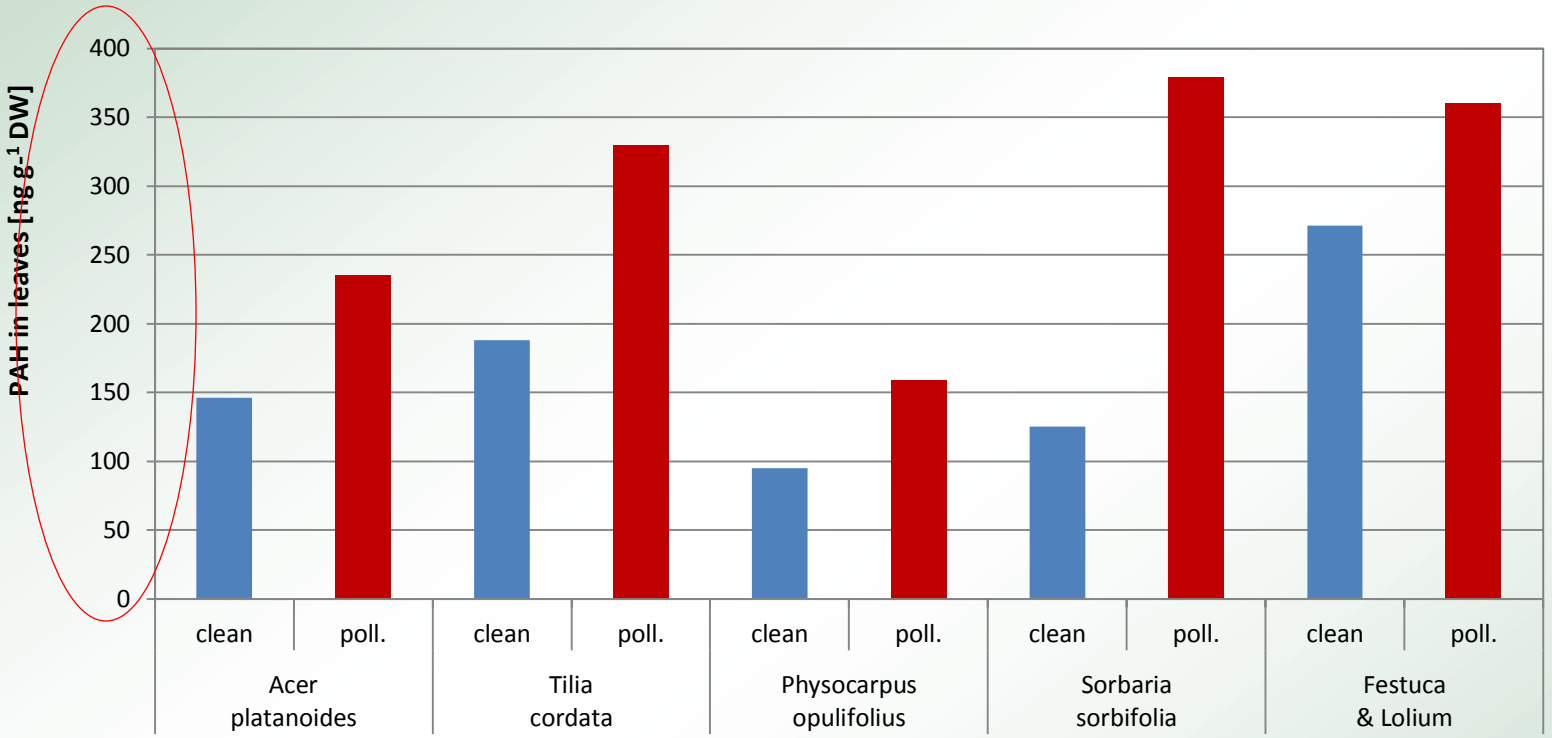
Compound	Ring number	Leavves not wased	Leaves washed with		average
			water	chloroform	
Acenaphtylene	3	6,0	5,5	7,5	6,3
Acenaphtene		20,0	15,5	14,5	16,6
Fluorene		37,0	34,3	34,3	35,2
Phenanthene		219,8	194,3	190,0	201,4
Anthracene		12,5	9,3	8,5	10,1
Fluoranthene	4	73,0	70,8	56,5	66,8
Pyrene		44,3	39,8	30,0	38,0
Benz[a]anthracene*		10,0	7,0	5,5	7,5
Chrysene*		18,5	18,5	8,8	15,3
Benzo[b]fluoranthene*	5	11,8	8,3	6,0	8,7
Benzo[k]fluoranthene*		5,8	4,8	3,8	4,8
Benzo[e]pyrene*		8,3	5,8	4,3	6,1
Benzo[a]pyrene*		7,5	3,8	4,3	6,1
Perylene		6,3	3,0	3,3	4,2
Dibenz[a,h]anthracene		5,0	5,0	5,0	5,6
Indeno[1,2,3c,d]pyrene*	6	6,3	5,0	5,8	5,7
Benzo[g,h,i]perylene		5.0	5,0	5,8	5,3
Total		497,1	435,7	395,7	442,8
*** Cancerigenic**		**85,7**	**76,5**	**53,8**	**72**

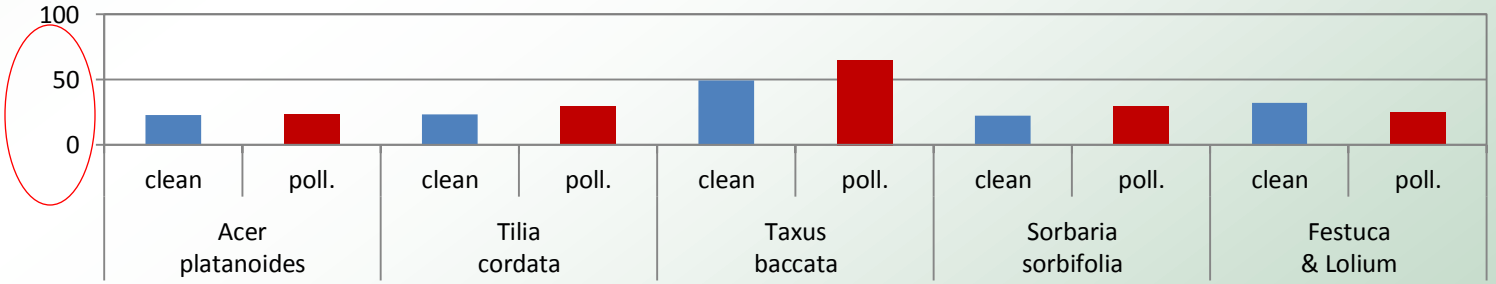
Penetration of fenatrene in epiderm cells



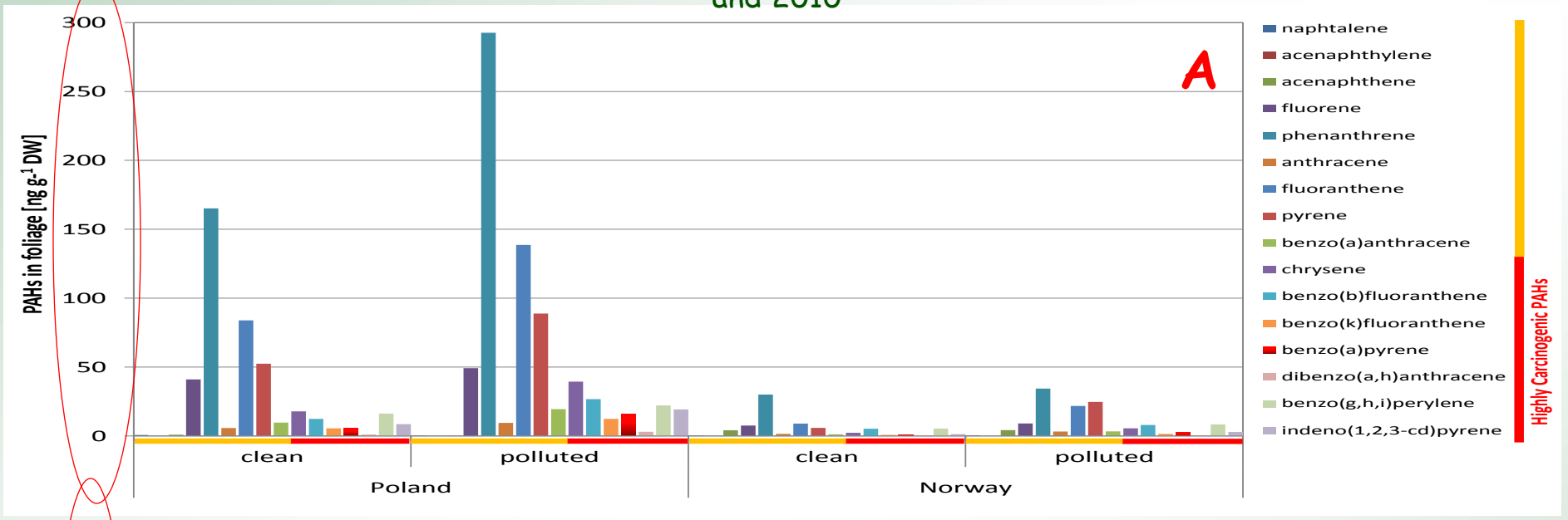
E. Wild et al., 2006. Environ.Sci.Technology

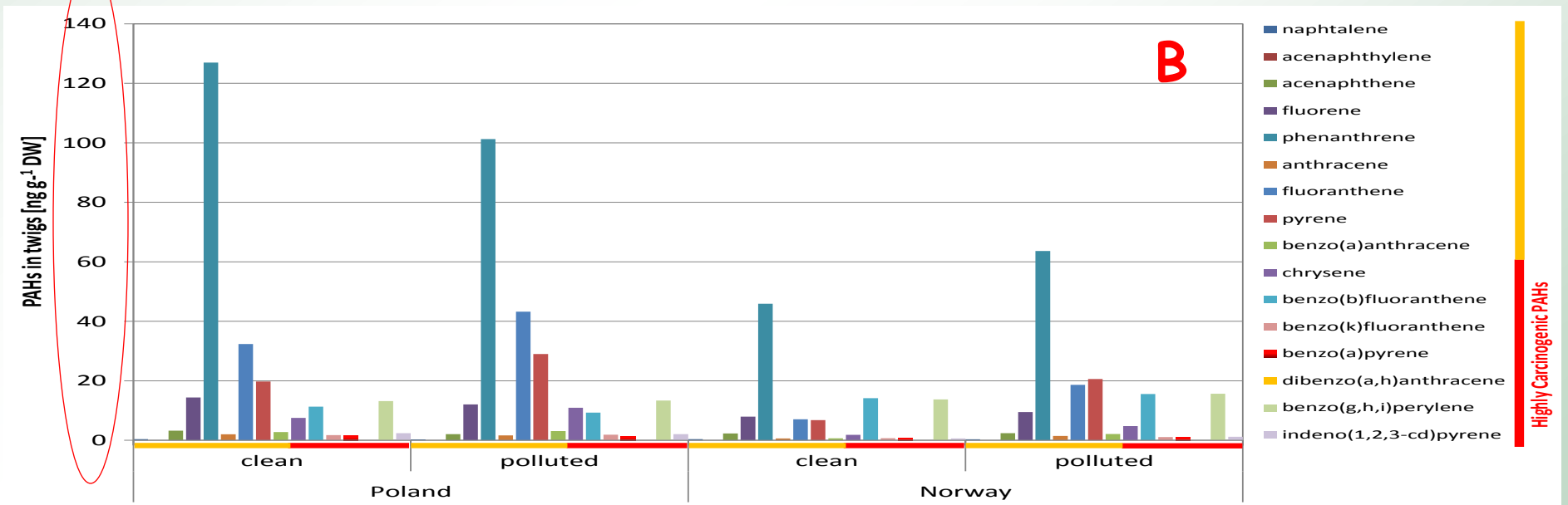
Concentration of phenantrene in leaves of six plant species cultivated at three locations (data are meam for 2009 and 2010).



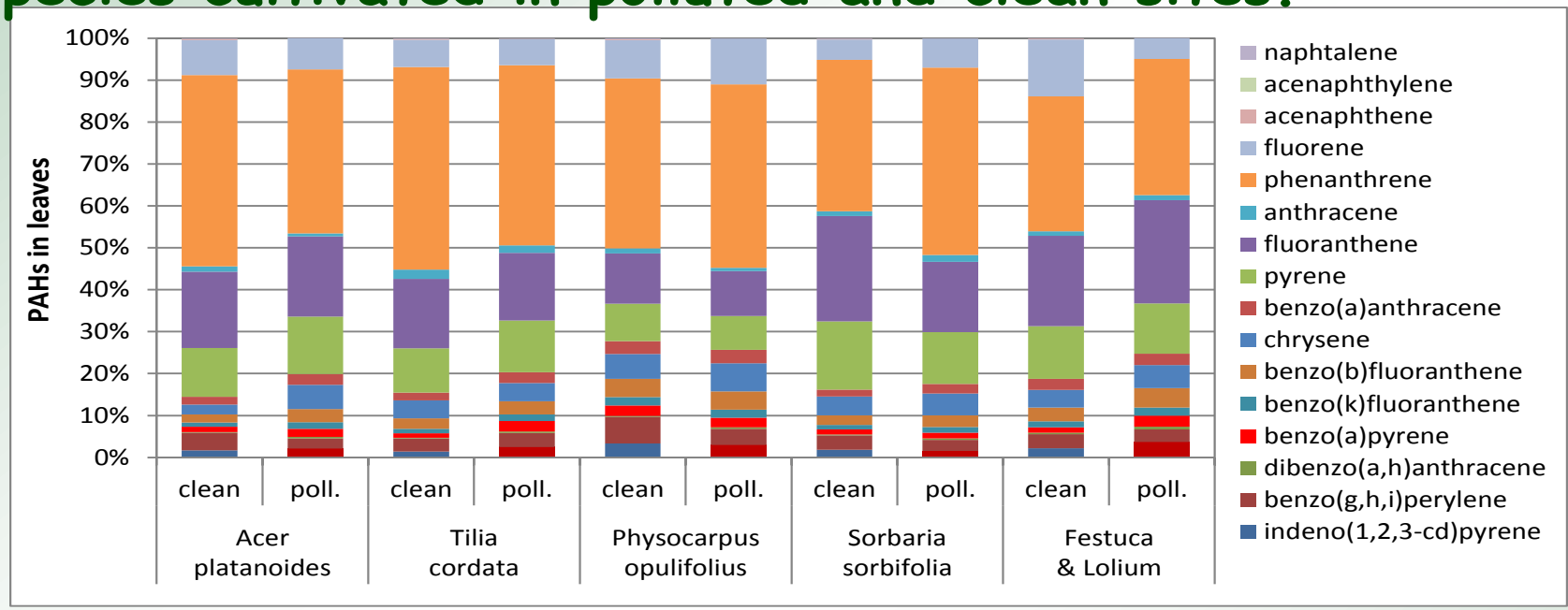


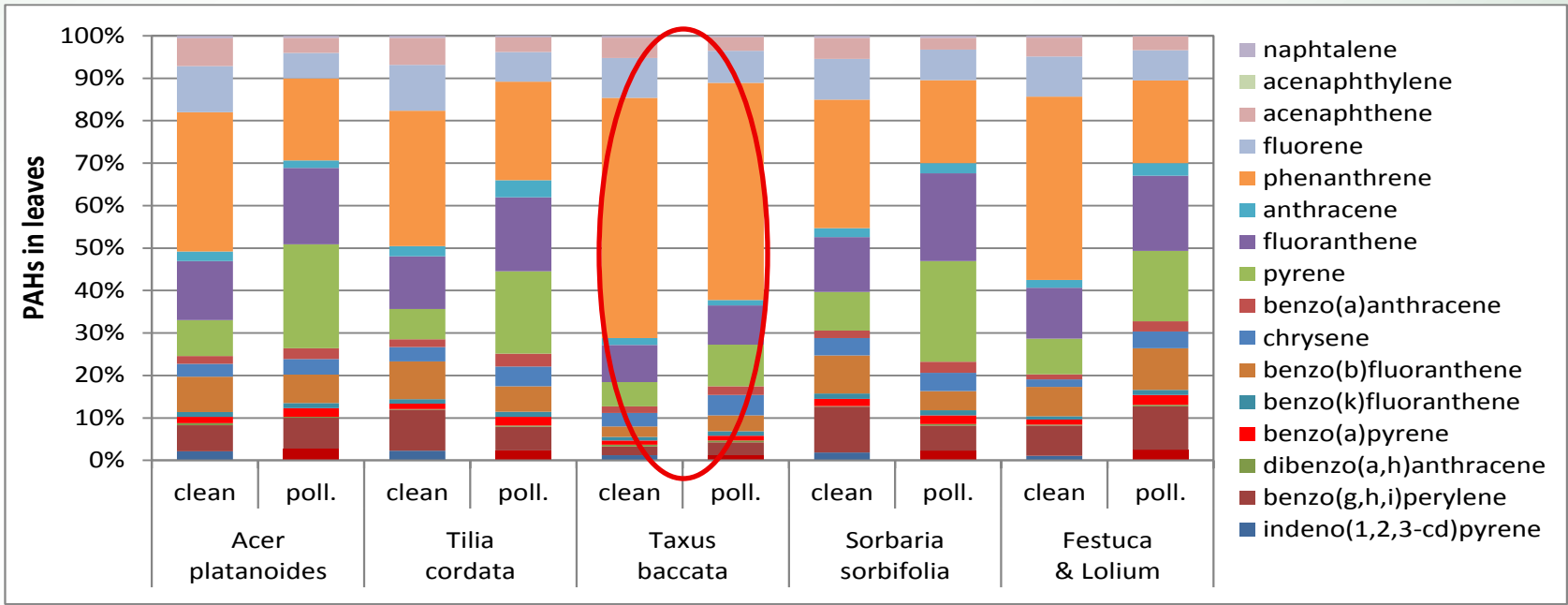
Concentration of 16 PAHs in (A) leaves and (B) twigs of six plant species cultivated in polluted and clean sites. Data are for 2009 and 2010



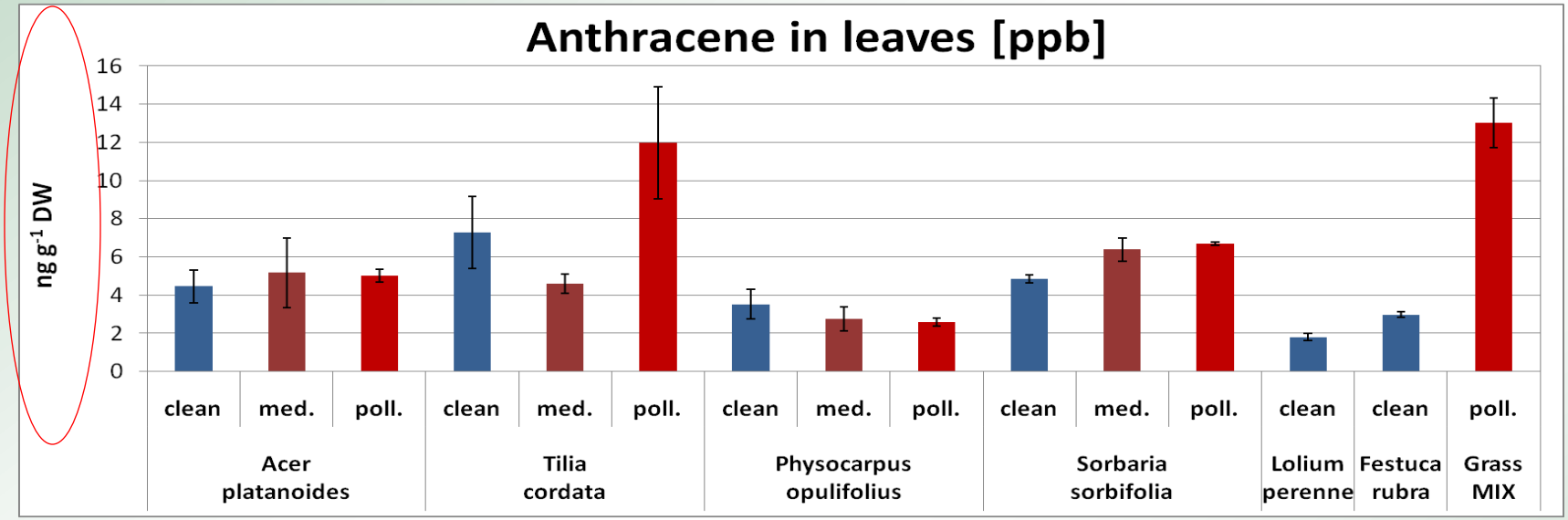


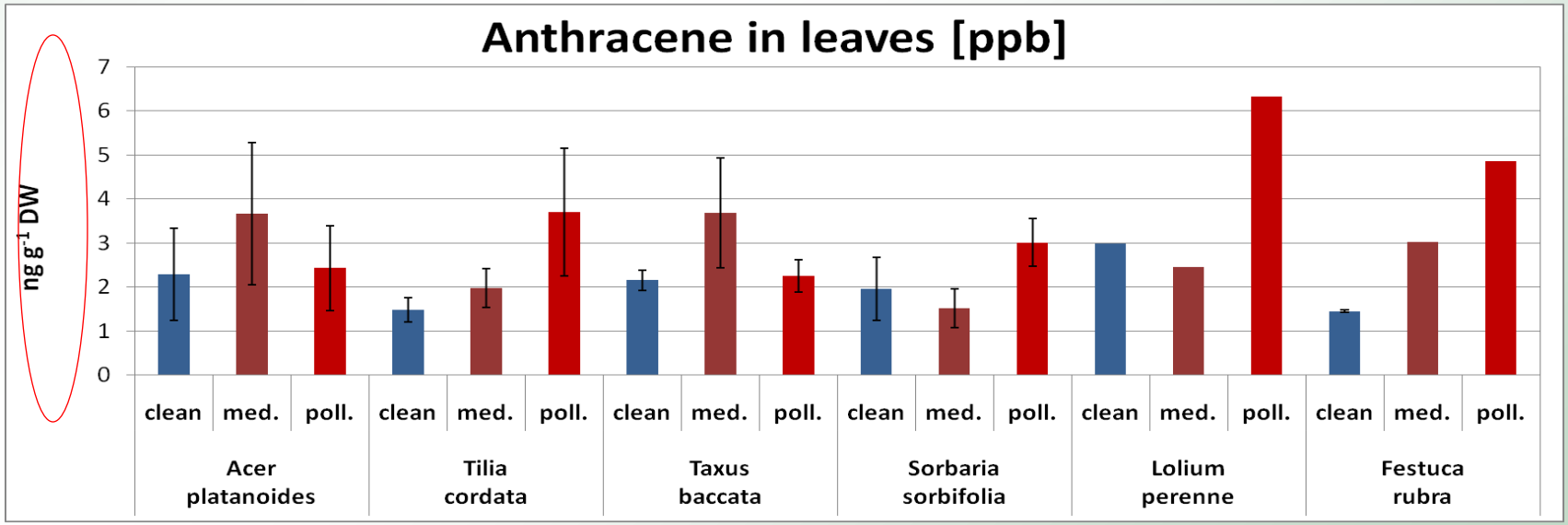
Contribution of particular PAHs in leaves of six plant species cultivated in polluted and clean sites.



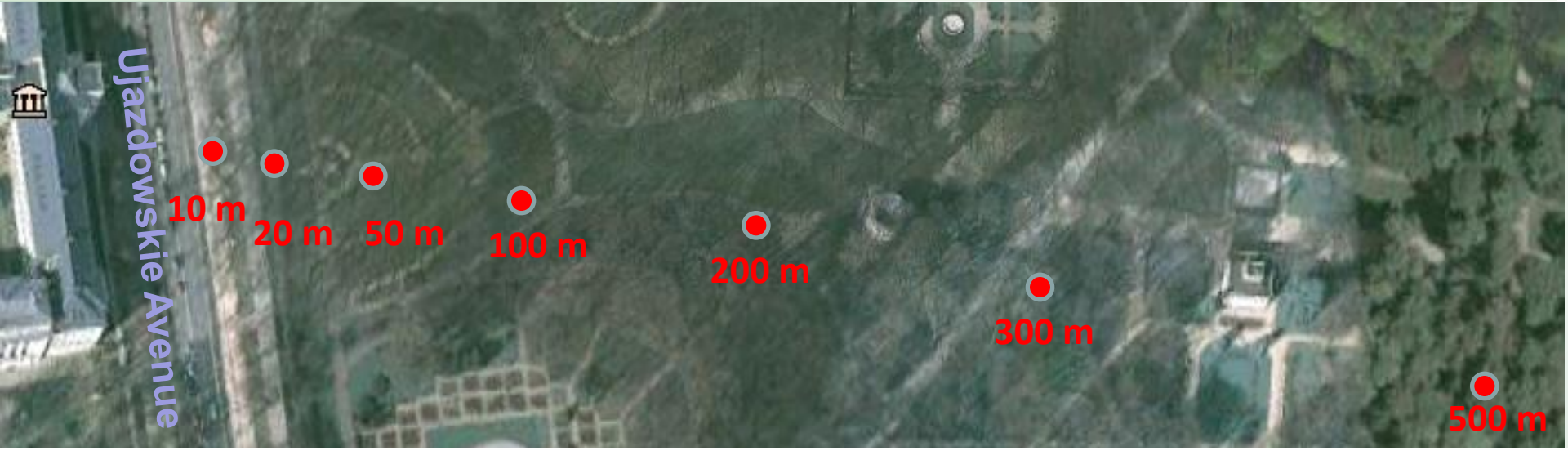


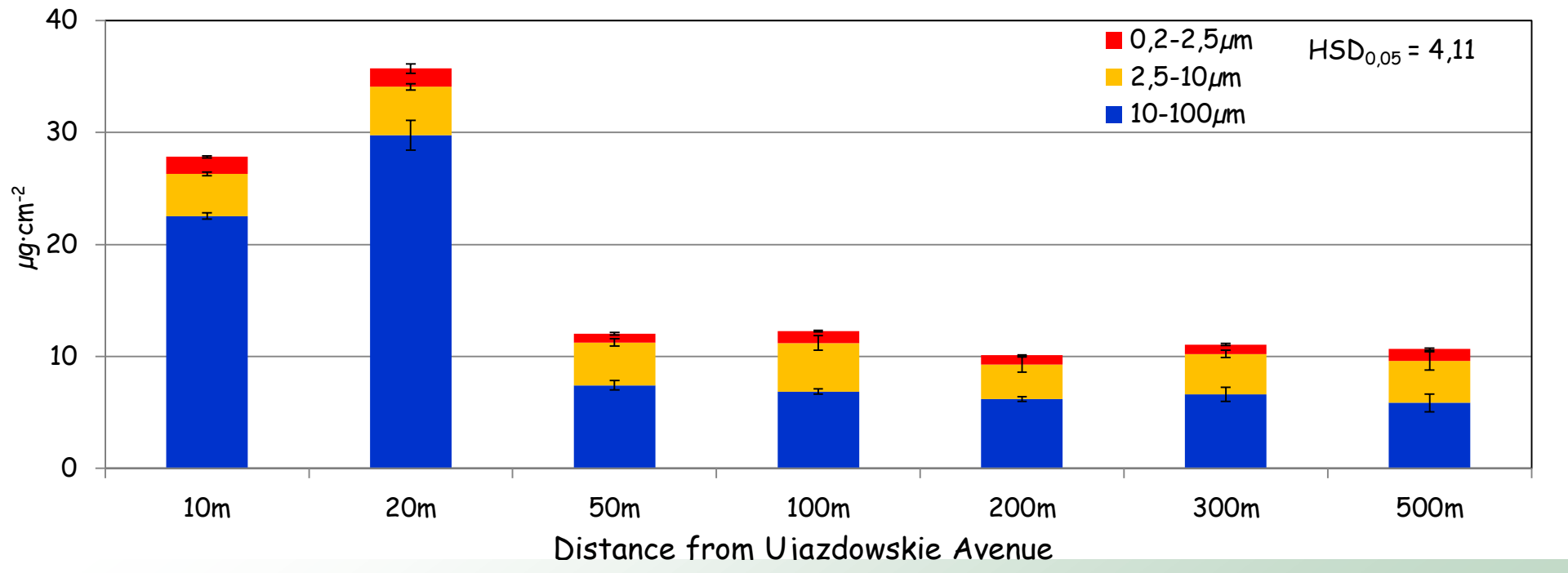
Concentration of antracene in leaves of six plant species cultivated at three locations. Data are mean for 2009 and 2010



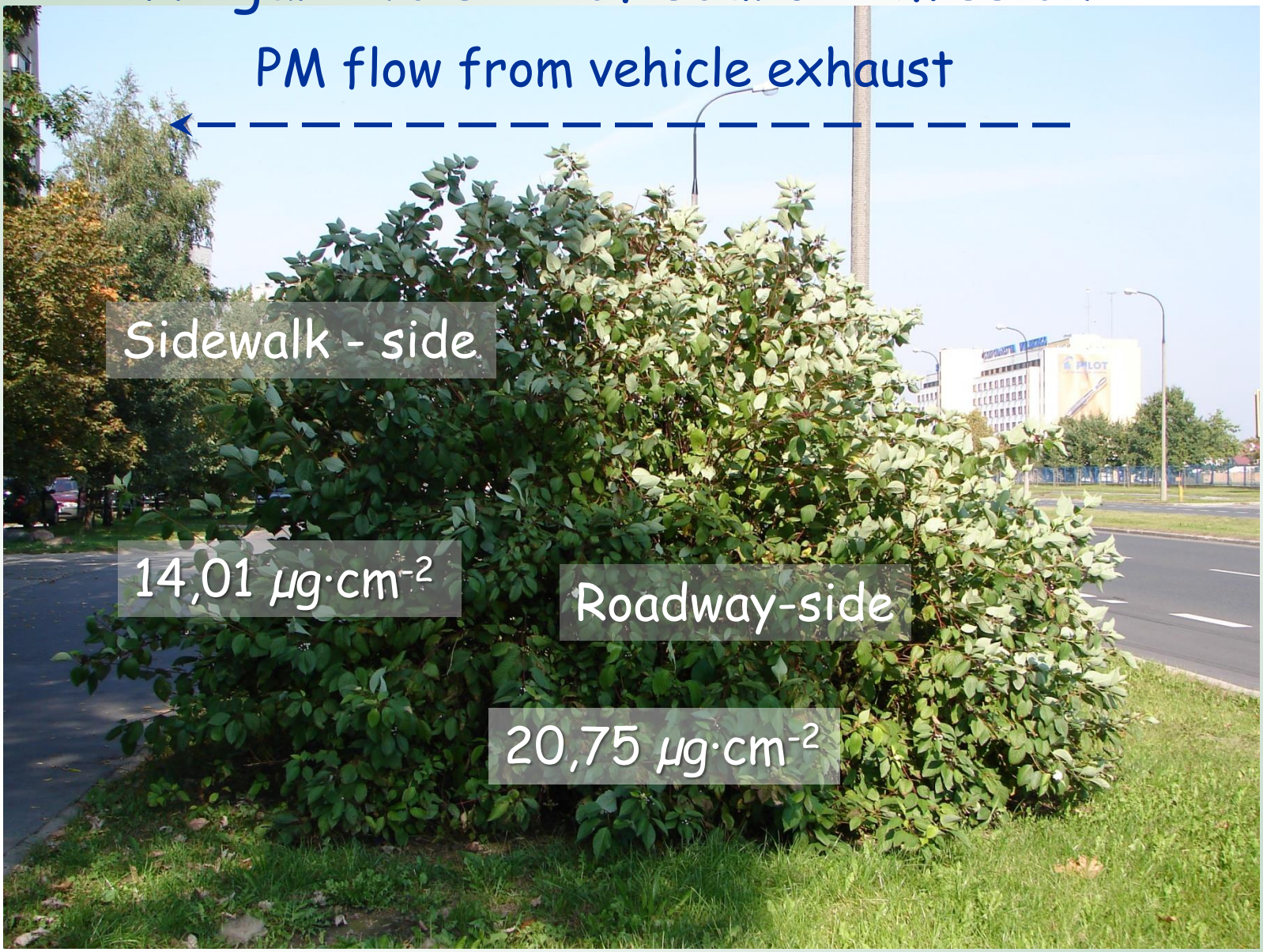


Particulate matter content on leaves of linden trees as affected by distance from emition

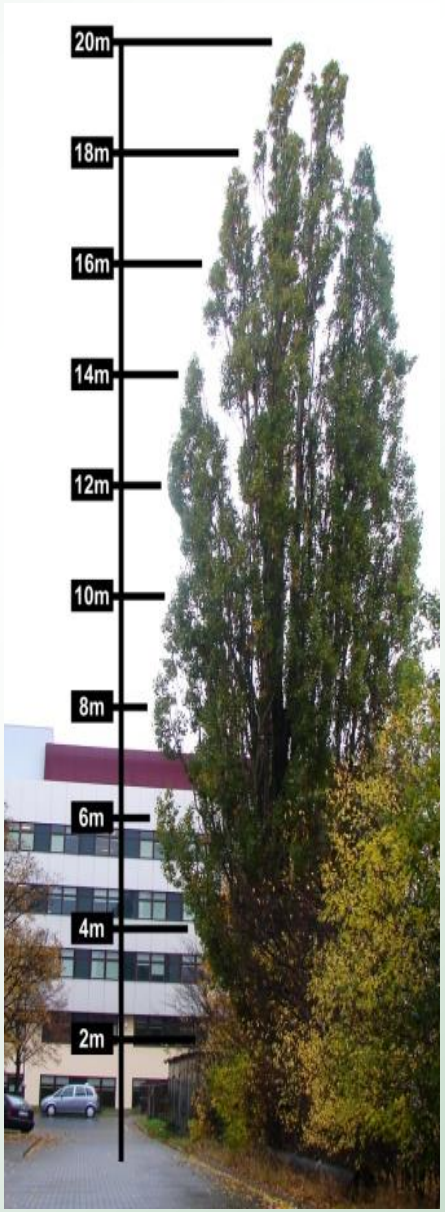




Amount of particulate matters deposited on leaves in regard to side of source emission



Leaves sample collecting for PM measurements regarding hight form source of emission



Leaves of average small-leaved lime tree in our study (~3,5 m crown height) accumulated:

4.81 g of PM

1.27 g of heavy metals

4.38 mg of PAHs


Barcelona 2013,
COST ActionTD 1105


Beijing, China 19 10 2008


Trees in urban areas may form a green tunnels
and accumulate air pollutants

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 μl/l

Formaldehyde enter plants via stomata and i epidermis

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* for metabolic and genetic modification is advanced (SO_2, NO_2, Cys-synthese activity

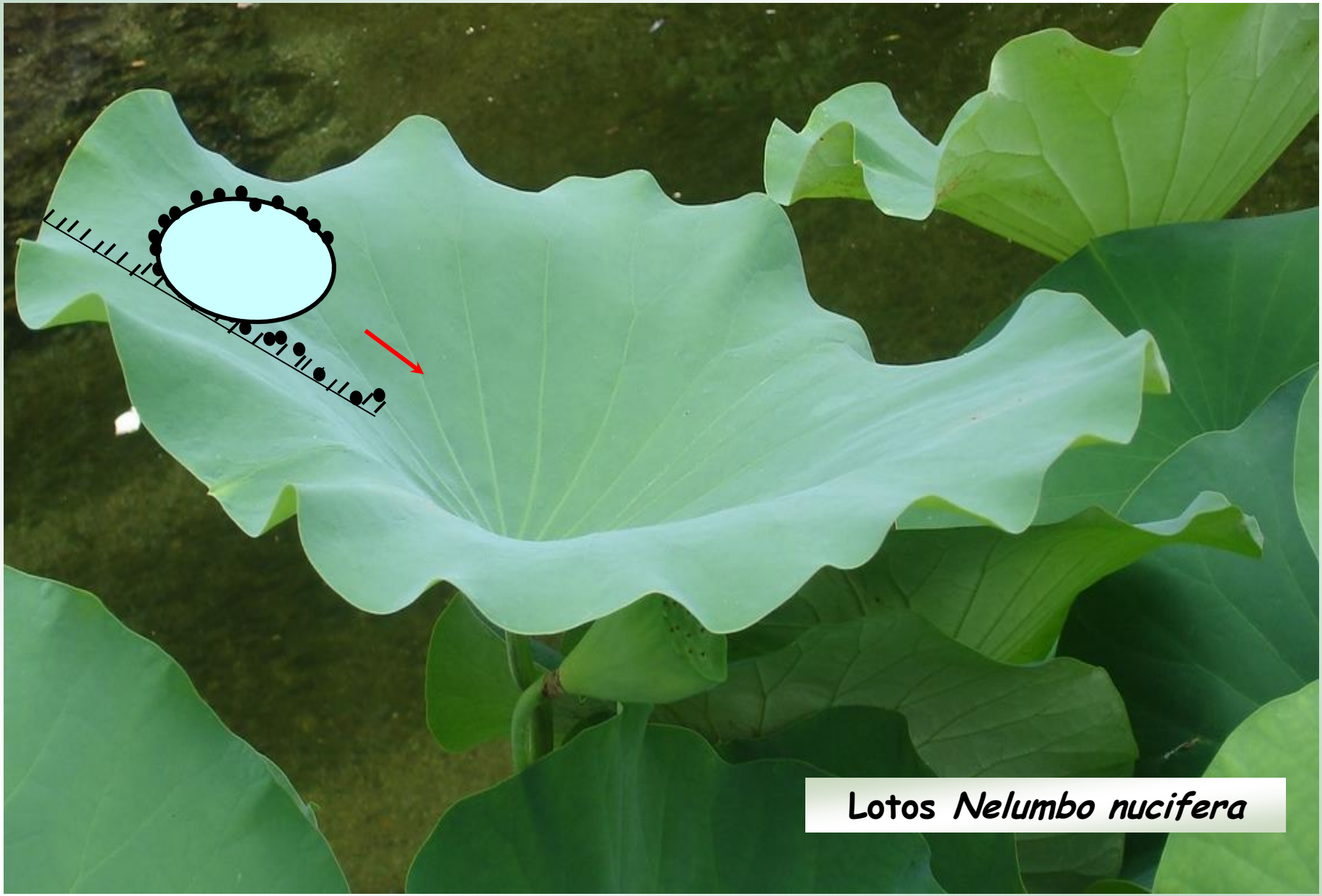

Ficus benjaminae

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 m2 and capacity of ~ 100m^3 formaldehyde at a concentration of 0.012 mg/m^3 will be removed completely in about 41 hours

Self „cleaning" of pollutants by leaves of lotus plants



This study was supported by a grant from Norway through the Norwegian Financial Mechanism, # PNRF-193-AI-1/07 granted to S.W. Gawronski and A. Sæbø and using equipment funded by Warsaw Plant Health Initiative of REGPOT Project within 7th FP #286093.

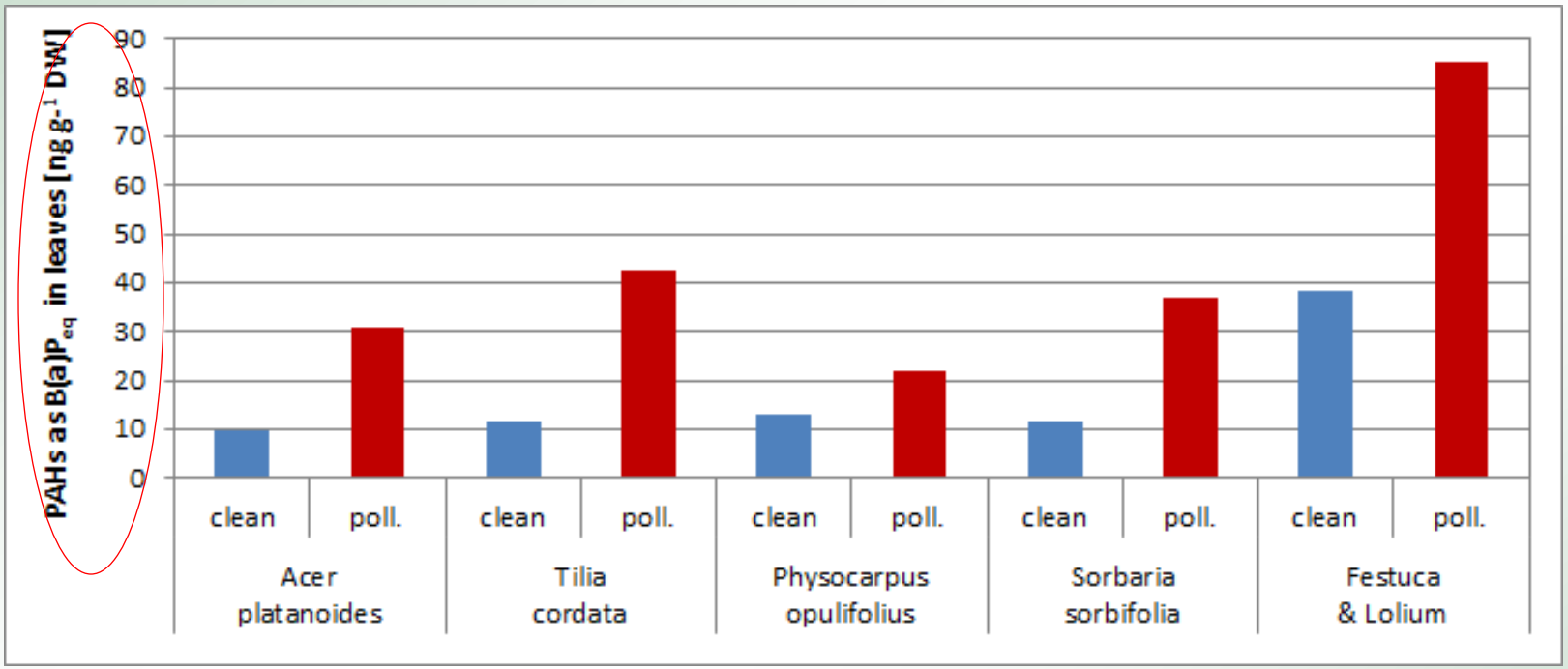
Thank you for your attention

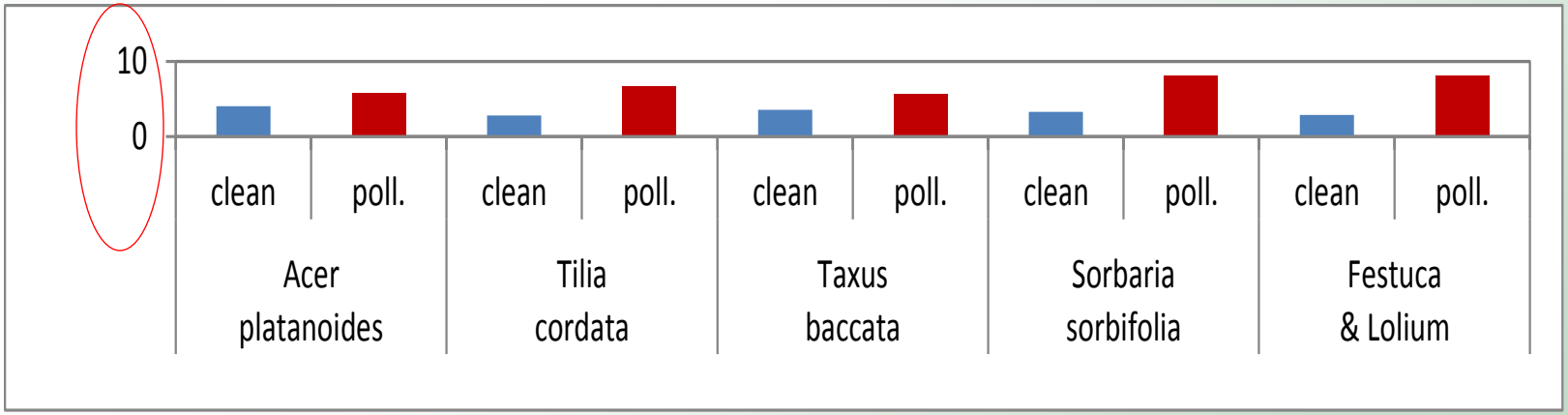
GREETINGS from and

WELCOME to Warsaw !!!

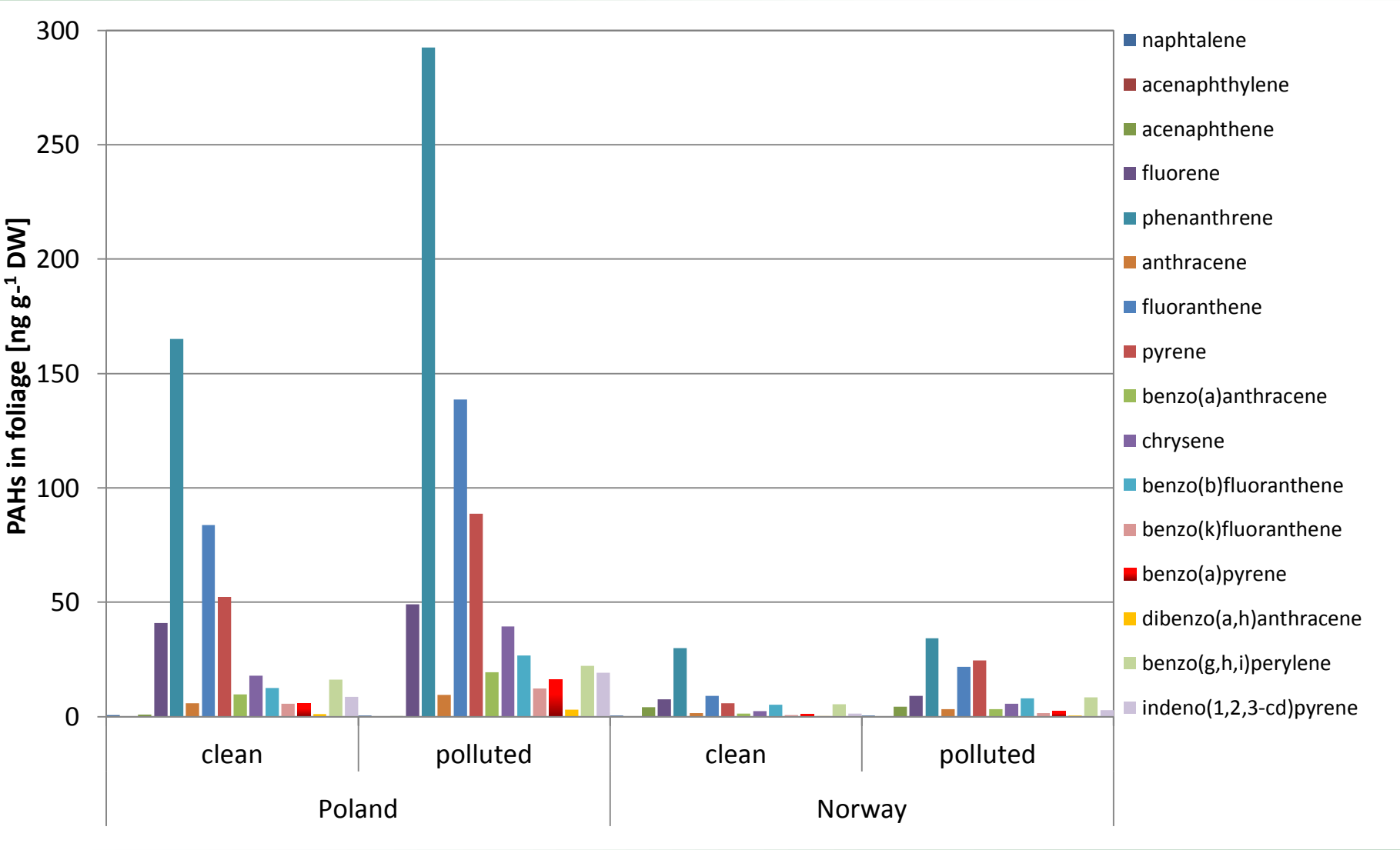
EXTRA SLIDES

Concentration of 16 PAS as equivalent of B(a)P in leaves of six plant species cultivated at three locations

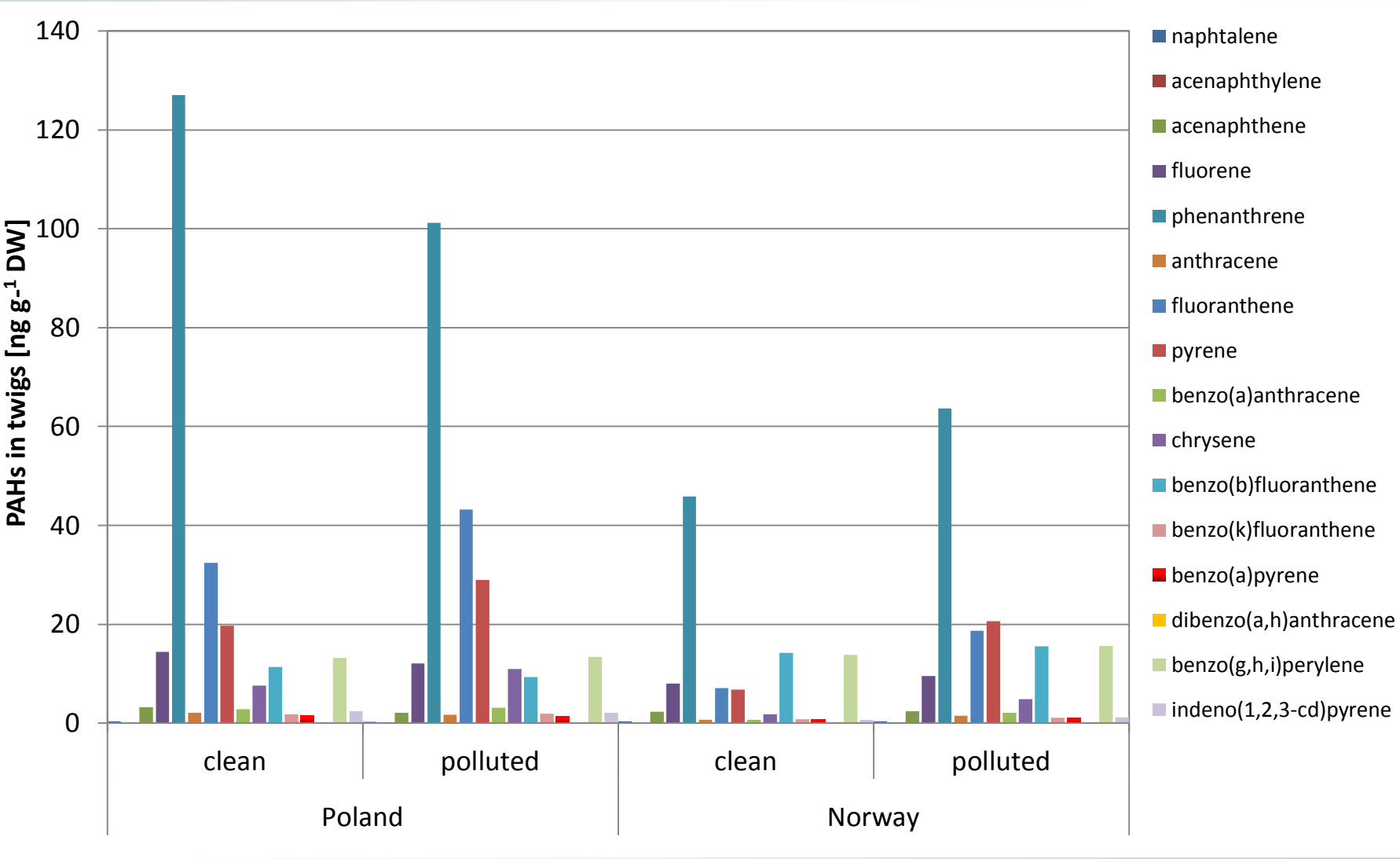




Średnia zawartość związków WWA w **LIŚCIACH** badanych roślin

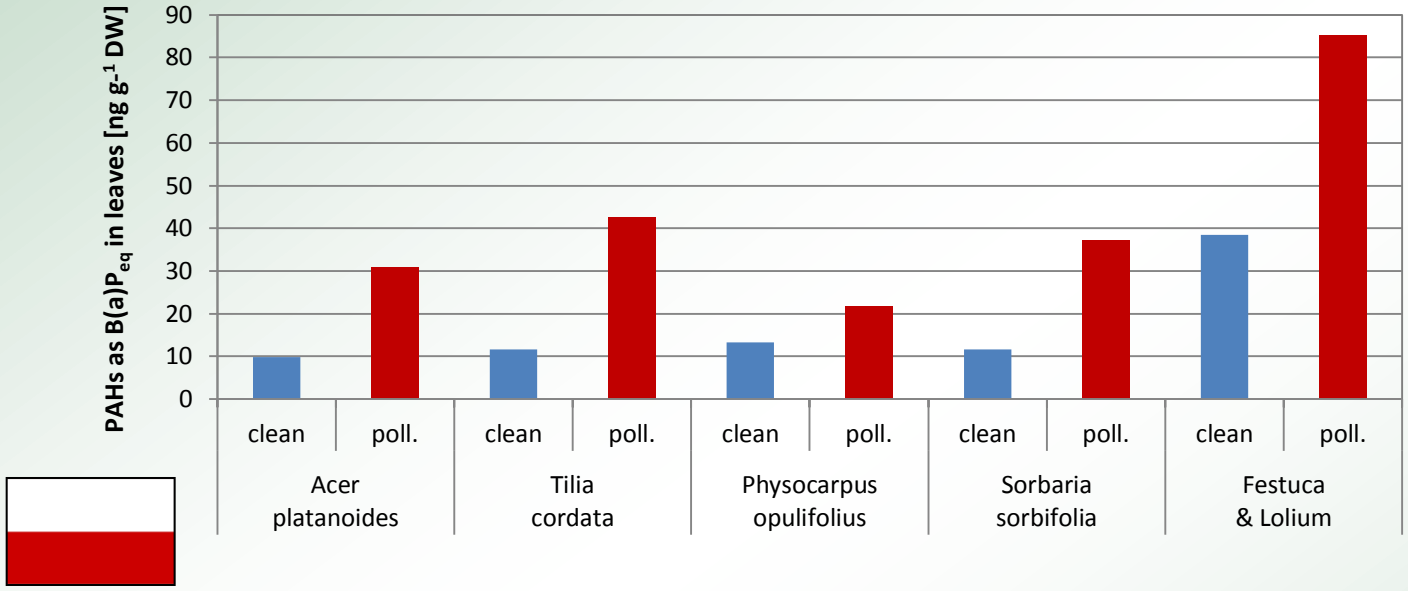


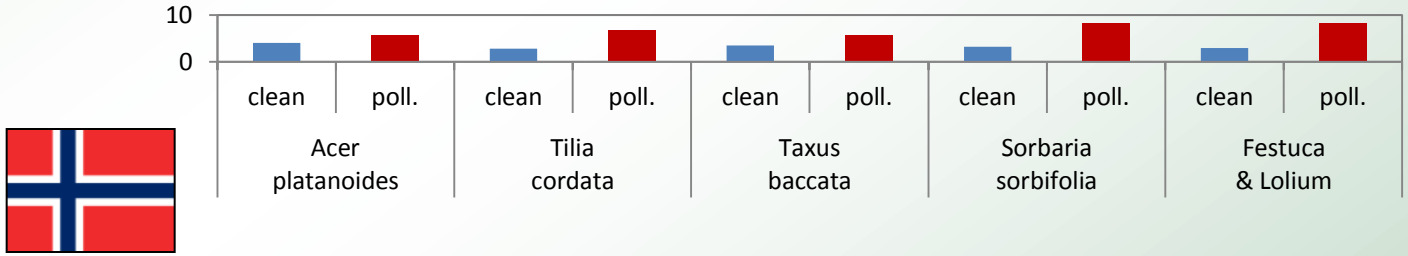
Średnia zawartość związków WWA w **PĘDACH** badanych roślin



Zawartość 16 WWA jako **$B(a)P_{eq}$** (ekwiwalent benzopirenu)

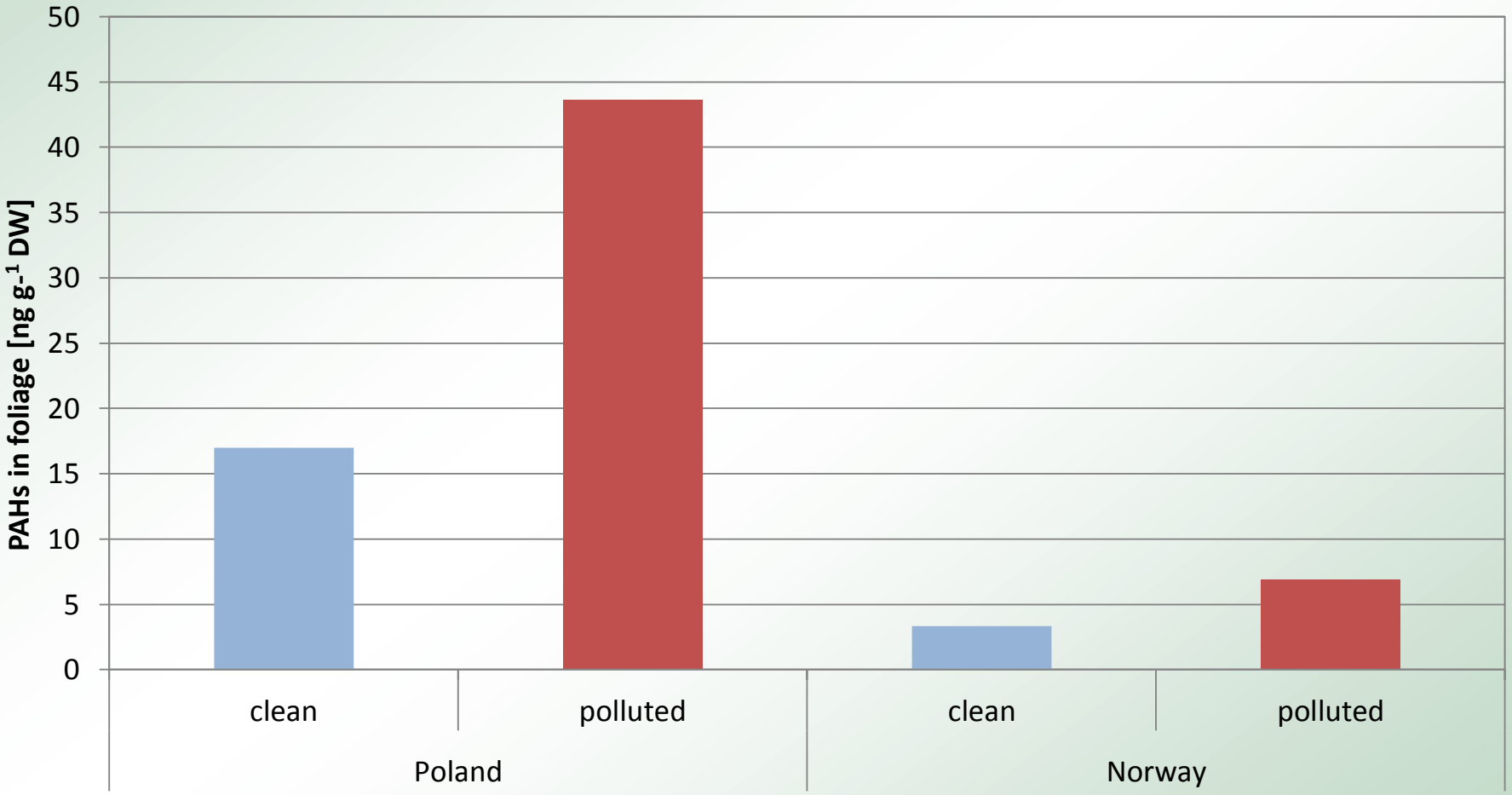
w **LIŚCIACH** badanych roślin





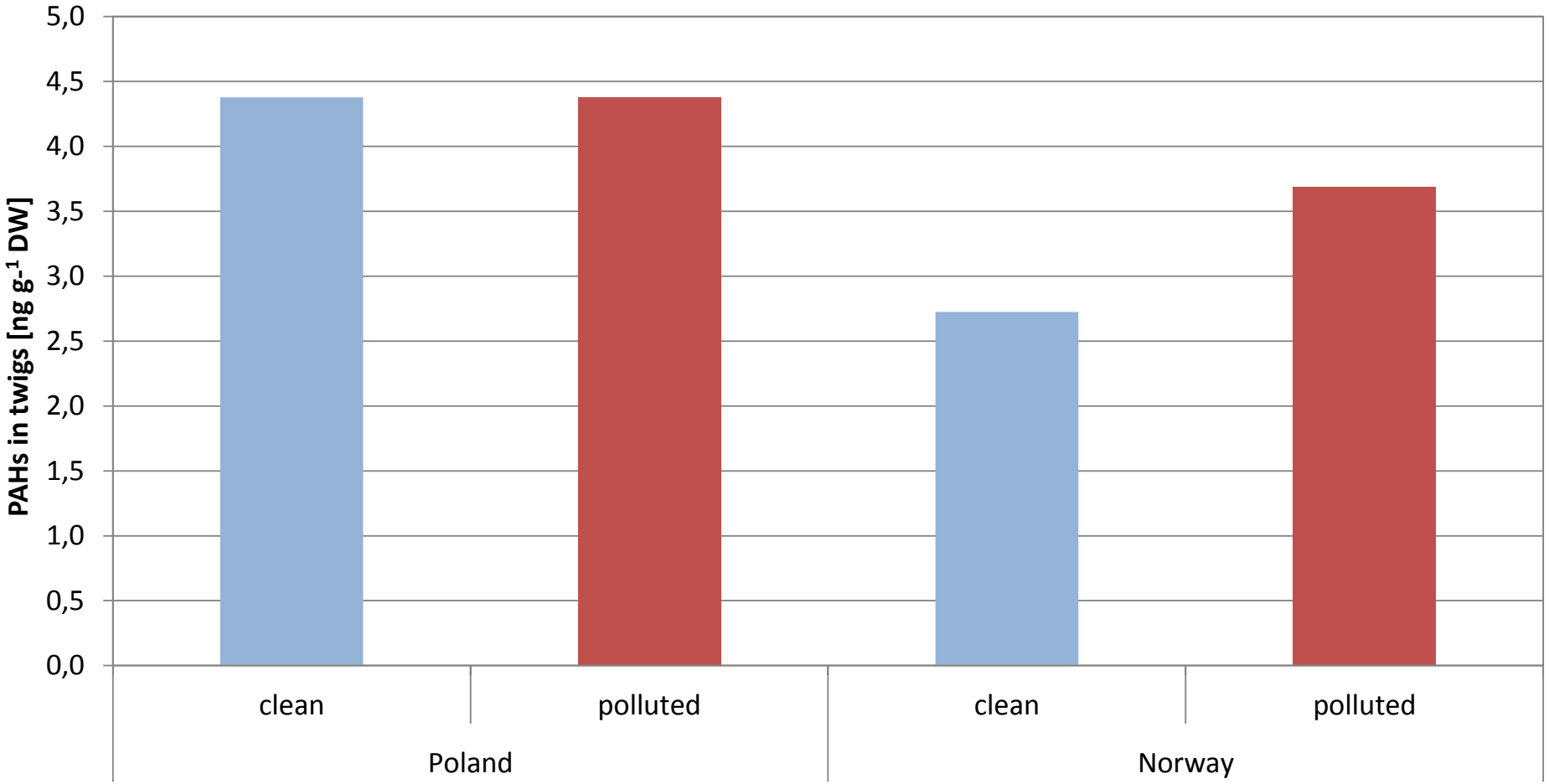
Zawartość 16 WWA jako **B(a)P$_{eq}$** (ekwiwalent benzopirenu)

w **LIŚCIACH** badanych roślin



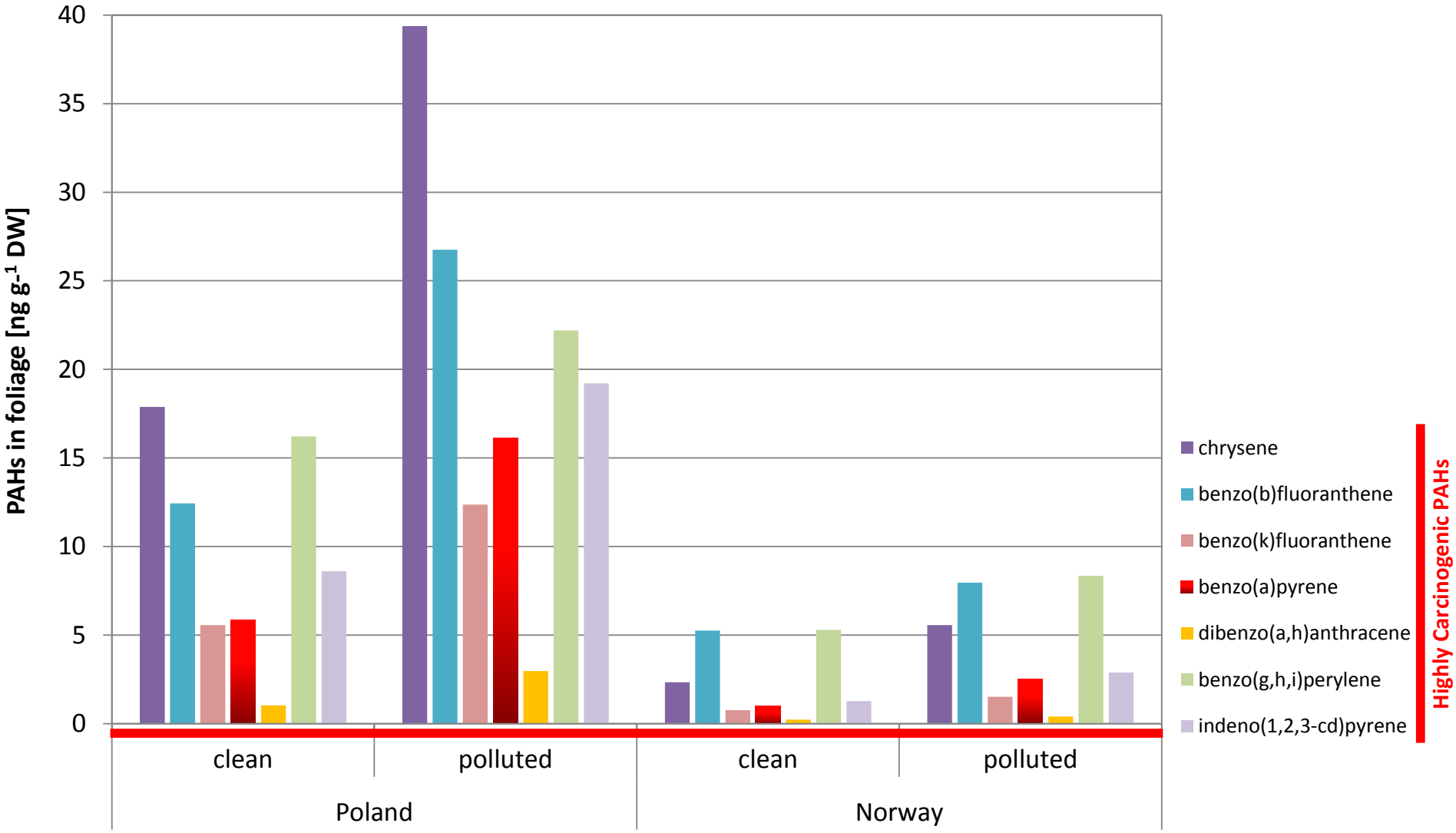
Zawartość 16 WWA jako **$B(a)P_{eq}$** (ekwiwalent benzopirenu)

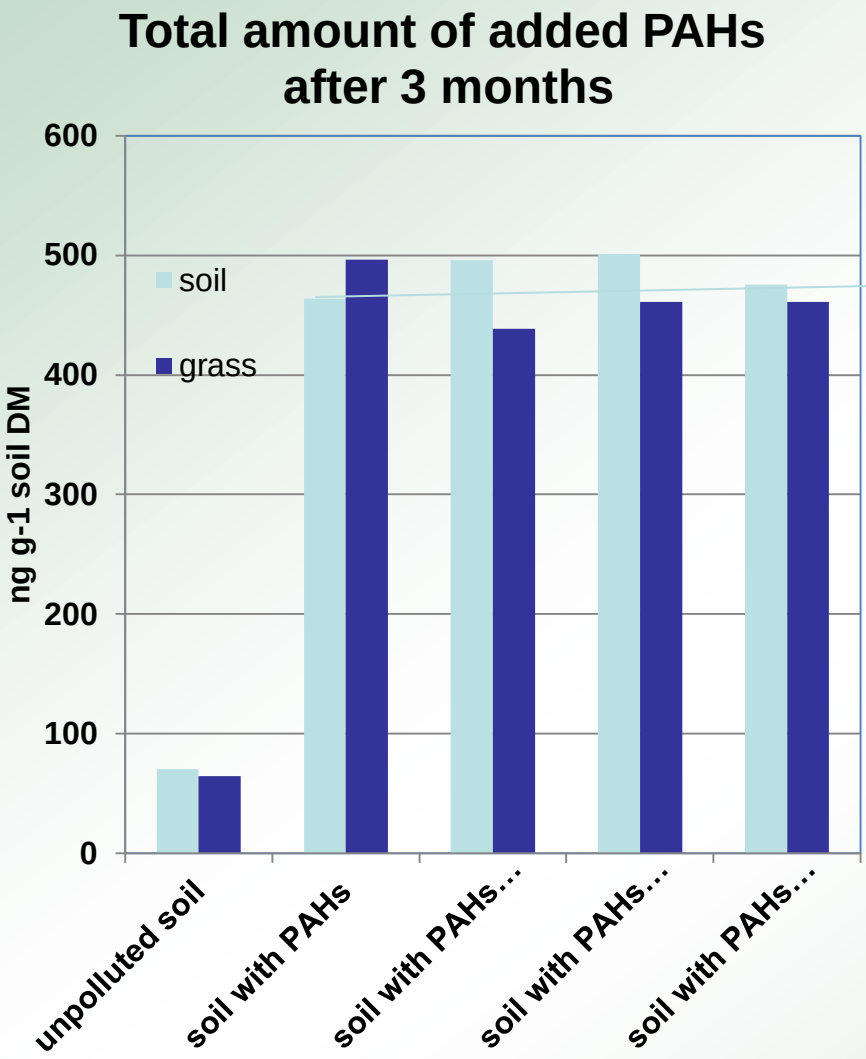
w **PĘDACH** badanych roślin

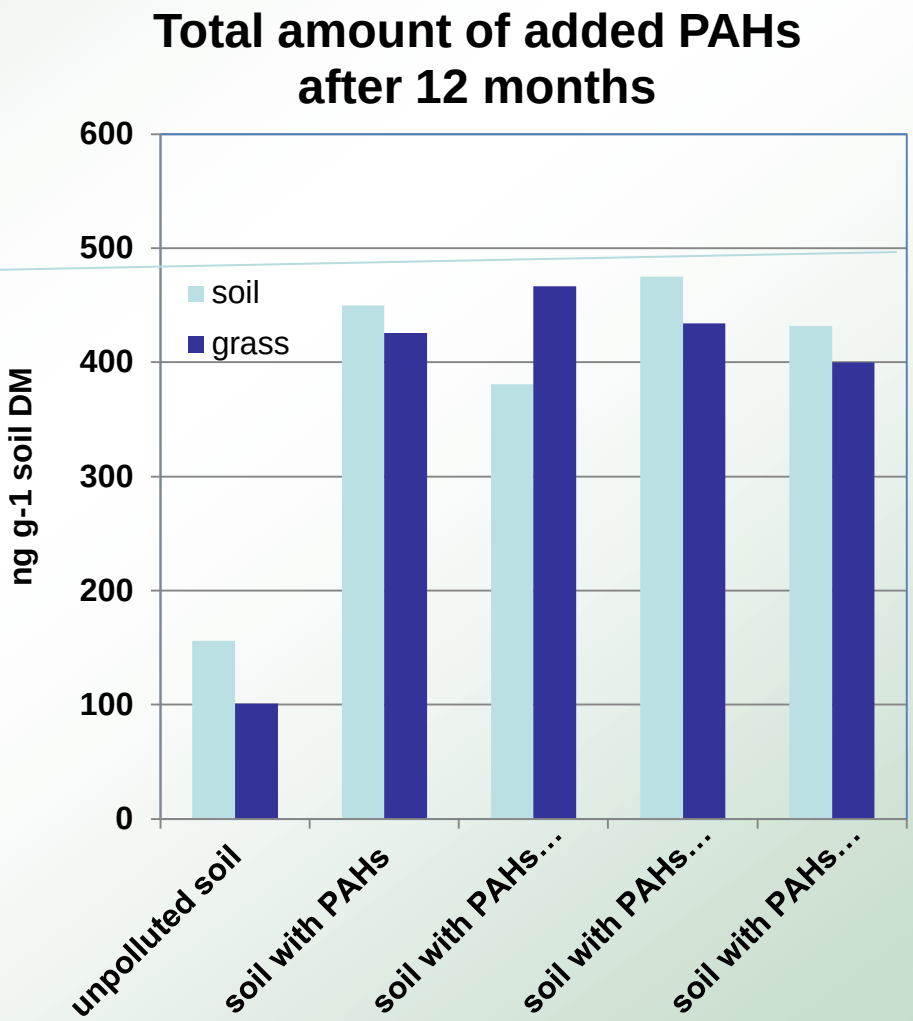


Średnia zawartość związków WWA w **LIŚCIACH** badanych roślin

(**same najbardziej kancerogenne WWA**)







Unpolluted soil = no added PAH

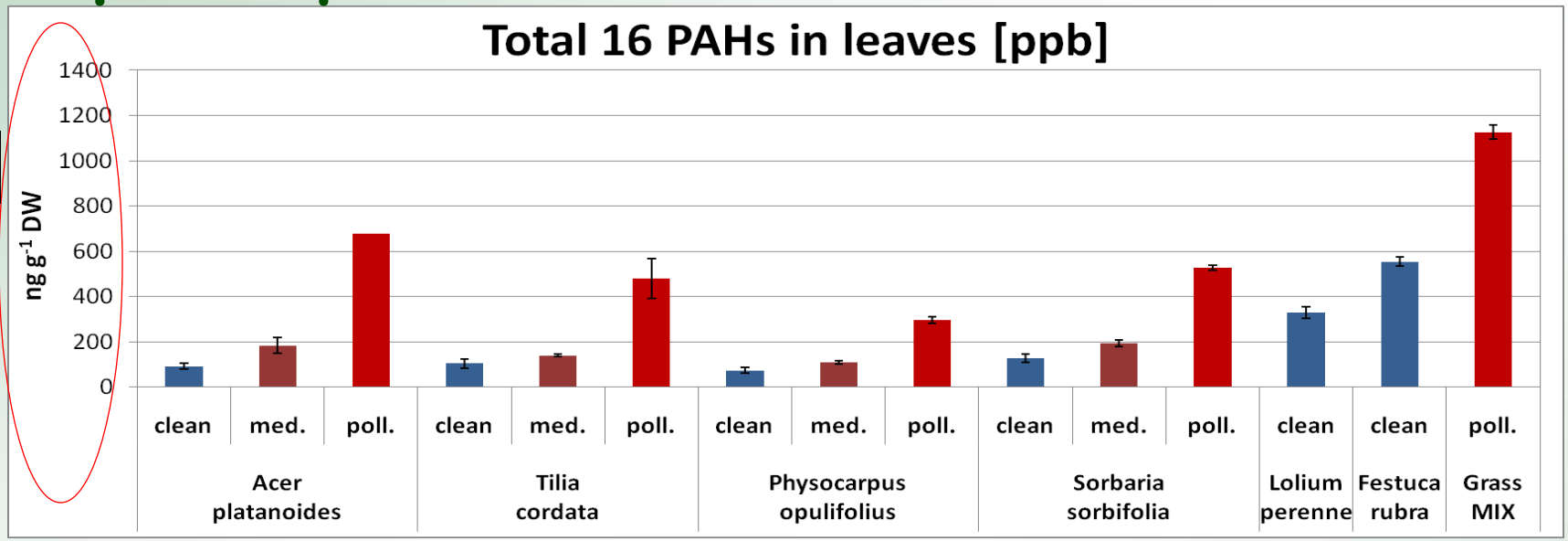
Locations of plants cultivation, differeing in level of air pollution, used for leaves sampling for PAHs content assay

Plant species used in studies:

Acer platanoides, Tilia cordata, Physocarpus opulifoius, Sorbaria sorbifolia, Lolium perenne, Festuca rubra (Poland).

In Norway *Physocarpus opulifoius was replaced by Taxus baccata*

Concentration of PAHs in leaves of six plant species cultivated at three locations



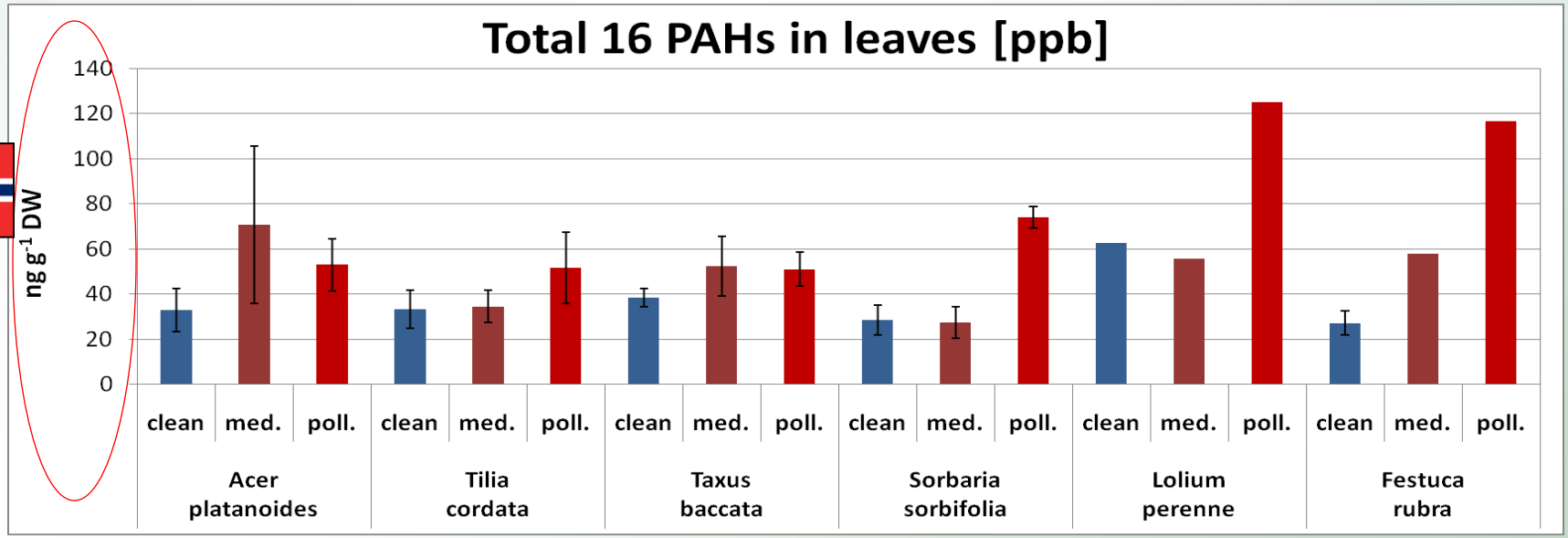
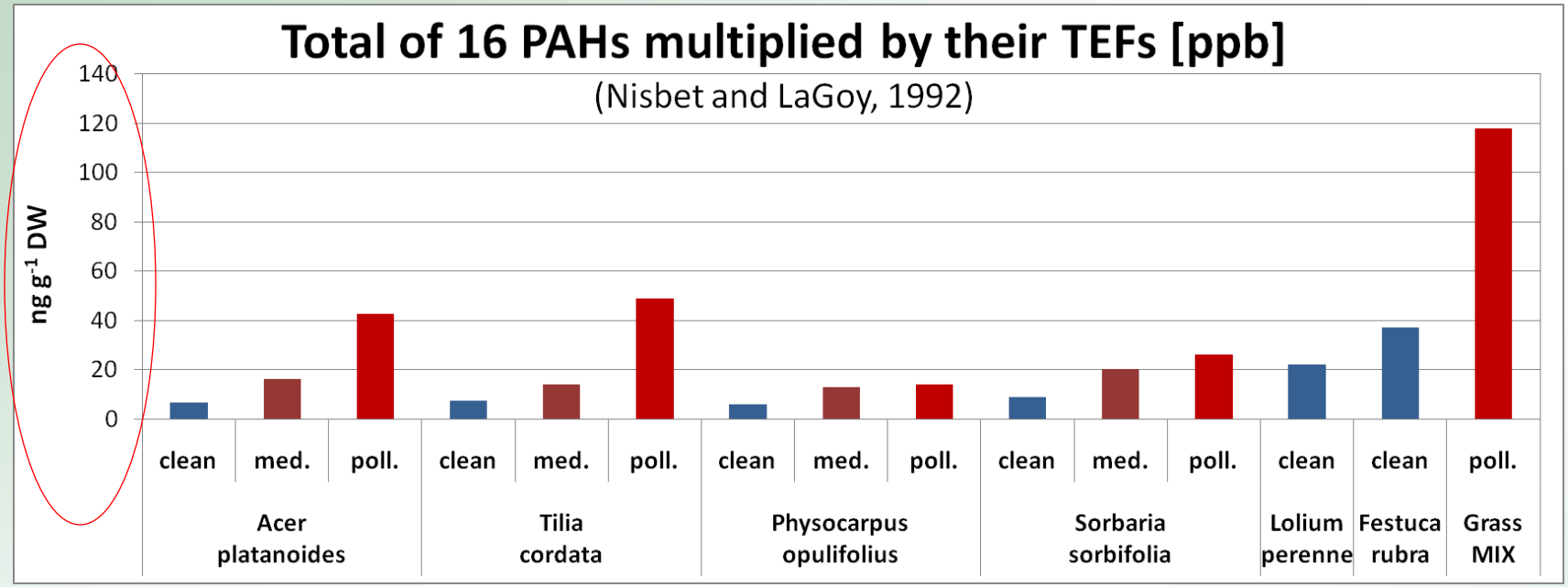


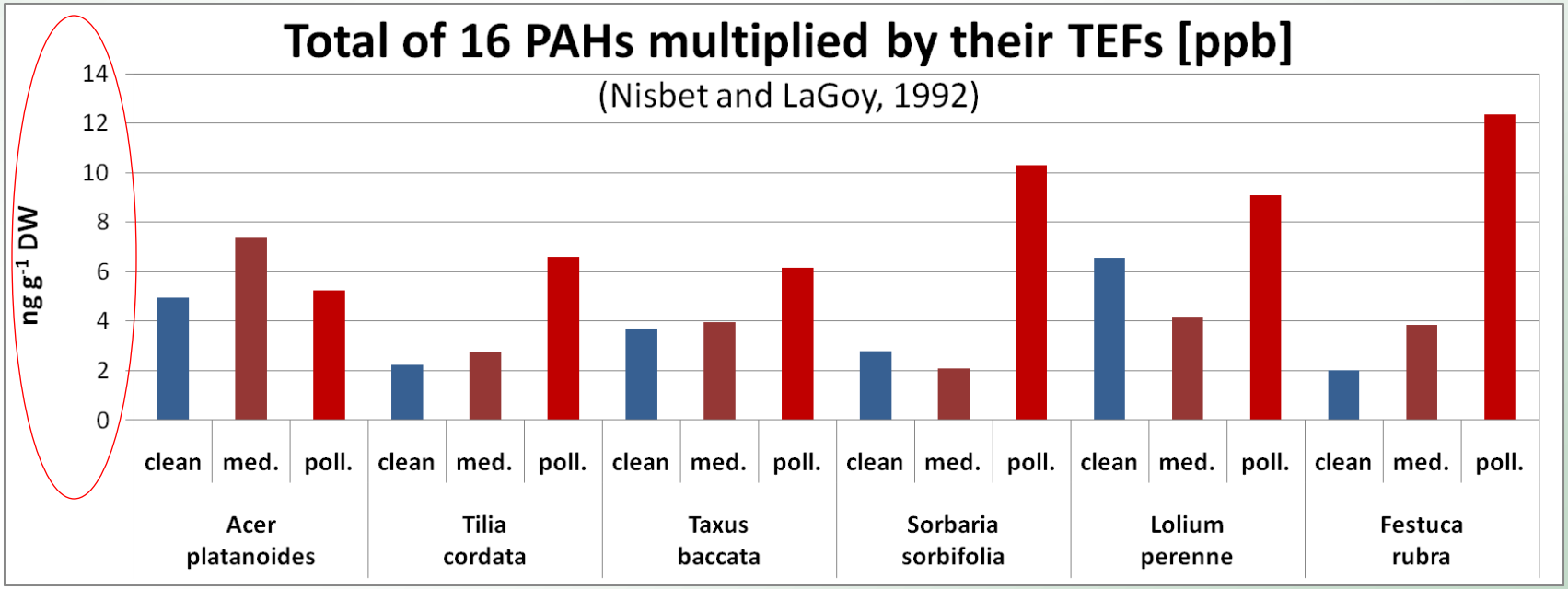
Table 1: Proposed Toxic Equivalency Factors (TEFs) for individual PAHs

Compound (Abbreviation)	CAS-Nr.	EPA (1984)	Chu and Chen (1984)	Clemens (1986)	Thorslund (1990)	Nisbet and LaGoy (1992)
Naphthalene (Naph)	91-20-3	0	ND	ND	ND	0.001
Acenaphthylene (Aceny)	208-96-8	0	ND	ND	ND	0.001
Acenaphthene (Ace)	83-32-9	0	ND	ND	ND	0.001
Fluorene (Flu)	86-73-7	0	ND	ND	ND	0.001
Phenanthrene (Phen)	8501-8	0	ND	ND	ND	0.001
Anthracene (Ant)	120-12-7	0	ND	0.32	ND	0.01
Fluoranthene (Fluor)	206-44-0	0	ND	ND	ND	0.001
Pyrene (Pyr)	129-00-0	0	ND	0.081	ND	0.001
Benzo(a)anthracene (BaA)	56-55-3	1	0.013	0.145	0.145	0.1
Chrysene (Chr)	219-01-9	1	0.001	0.0044	0.0044	0.01
Benzo(j+b)fluoranthene (BjbF)	205-99-2	1	0.08	0.14	0.12	0.1
Benzo(k)fluoranthene (BkF)	207-08-9	1	0.004	0.066	0.052	0.1
Benzo(a)pyrene (BaP)	50-32-8	1	1	1	1	1
Indeno(1.2.3-cd)pyrene (IND)	193-39-5	1	0.017	0.232	0.278	0.1
Dibenzo(ah)anthracene (DahA)	53-70-3	1	0.69	1.1	1.11	1
Benzo(ghi)perylene (BgP)	191-24-2	0	ND	0.022	0.021	0.01

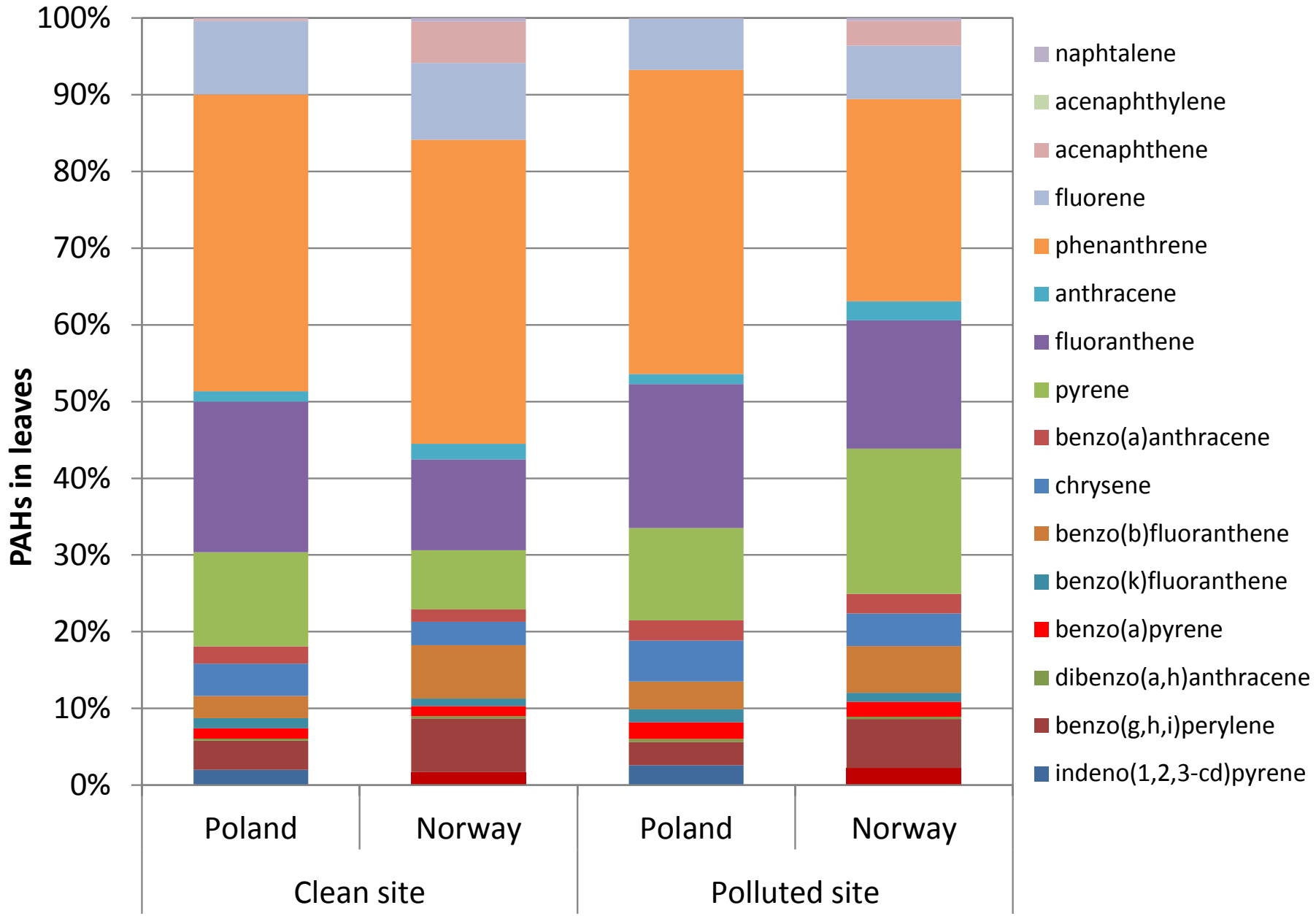
ND: No Data

Source: Petry T., Schmid P., Schlatter C., 1996. The use of toxic equivalency factors in assessing occupational and environmental health risk associated with exposure to airborne mixtures of polycyclic aromatic hydrocarbons (PAHs). *Chemosphere* 32(4): 639-648.

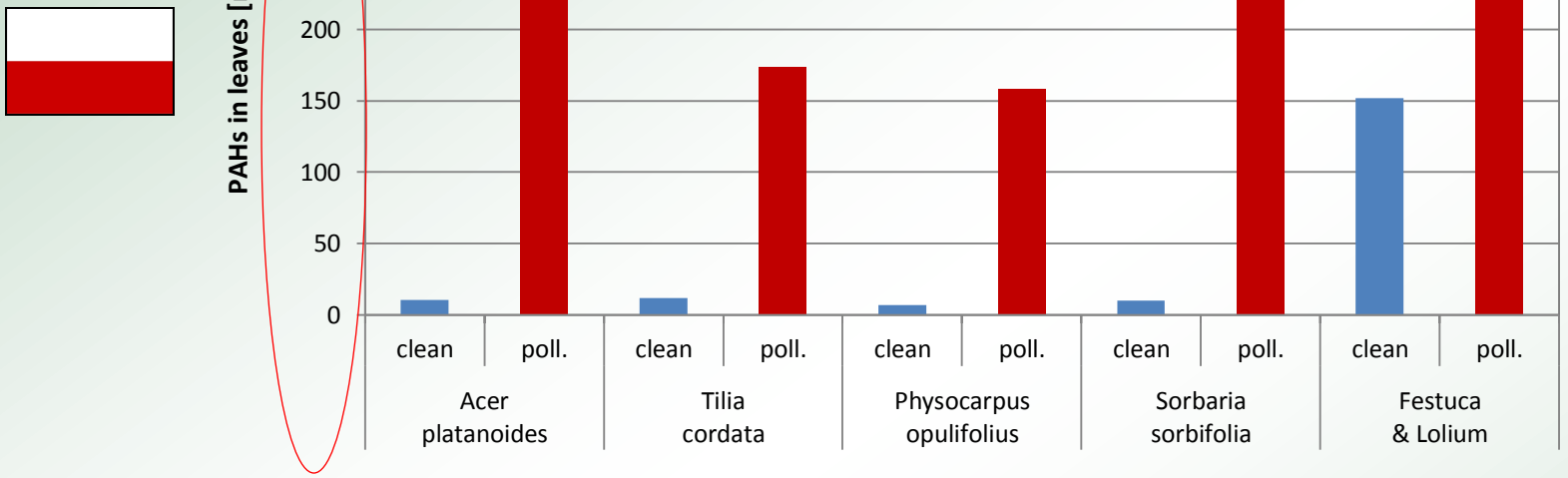

Total of 16 PAHs multiplied by their TEFs [ppb]
(Nisbet and LaGoy, 1992)
ng g-1 DW
140
120
100
80
60
40
20
0
clean
med.
poll.
Acer platanoides
Tilia cordata
Physocarpus opulifolius
Sorbaria sorbifolia
Lolium perenne
Festuca rubra
Grass MIX

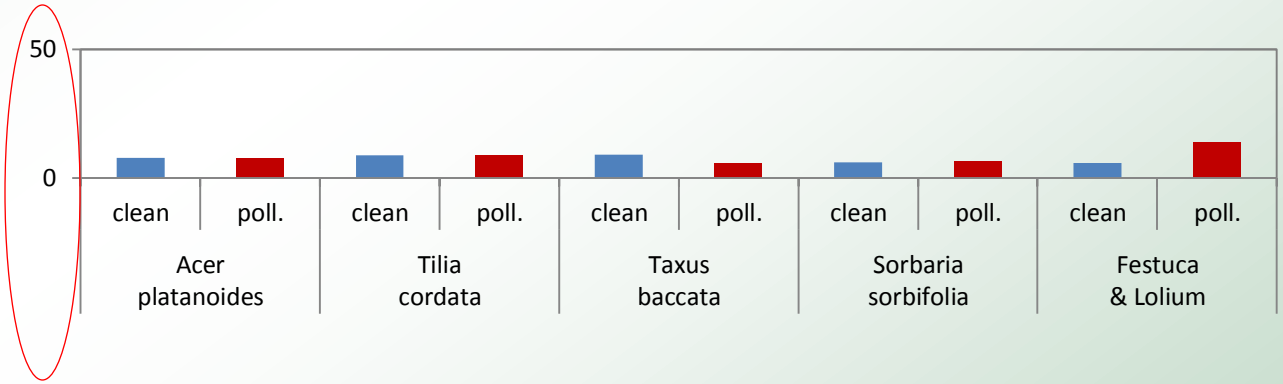

Total of 16 PAHs multiplied by their TEFs [ppb]
(Nisbet and LaGoy, 1992)
ng g-1 DW
14
12
10
8
6
4
2
0
clean
med.
poll.
Acer platanoides
Tilia cordata
Taxus baccata
Sorbaria sorbifolia
Lolium perenne
Festuca rubra

Contribution of particular PAHs in leaves of six plant species cultivated in polluted and clean sites. Data are mean for 2009 and 2010

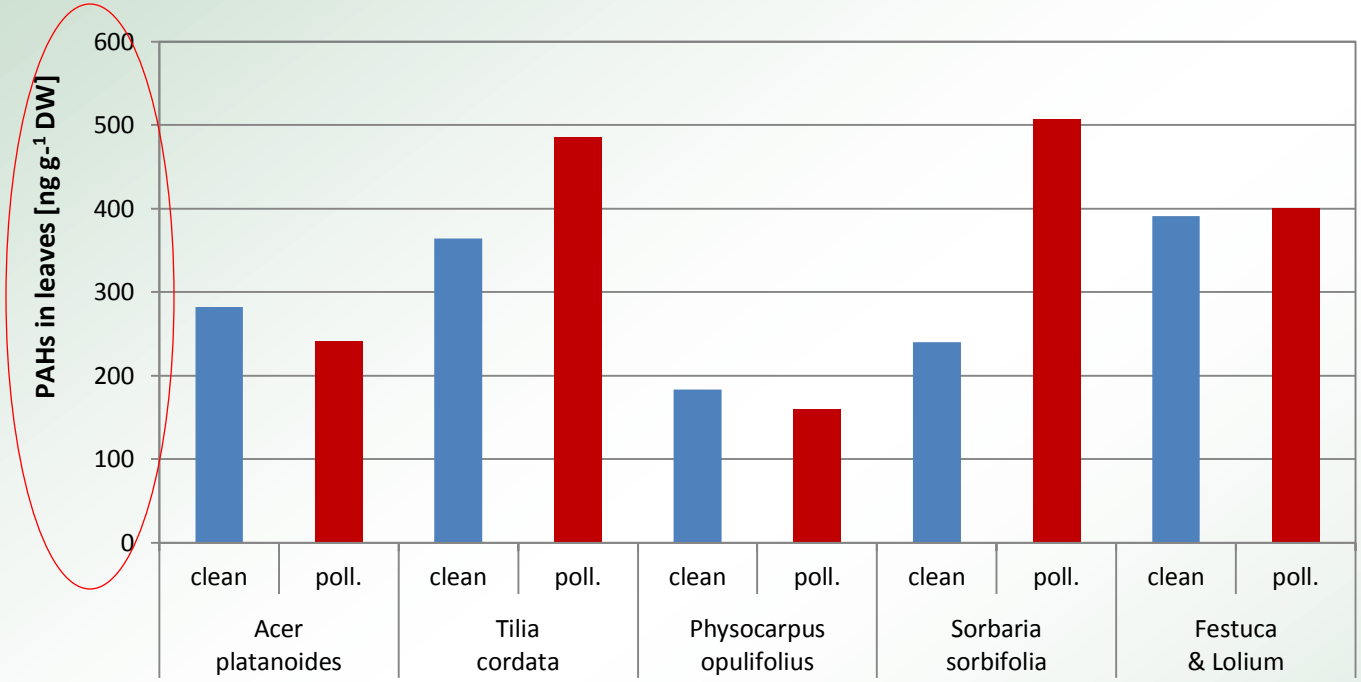


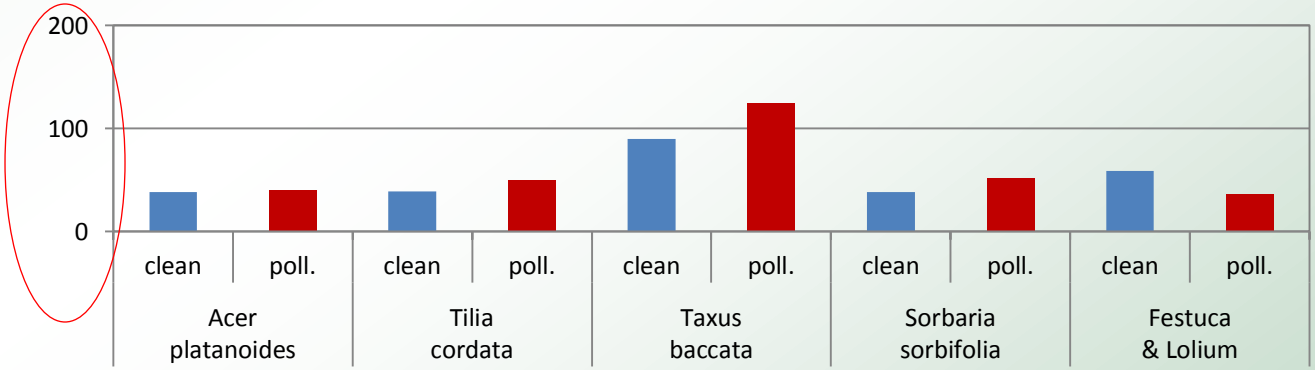
Concentration of phenantrene in leaves of six plant species cultivated at three locations. Data for 2009.





Concentration of phenantrene in leaves of six plant species cultivated at three locations. Data for 2010.

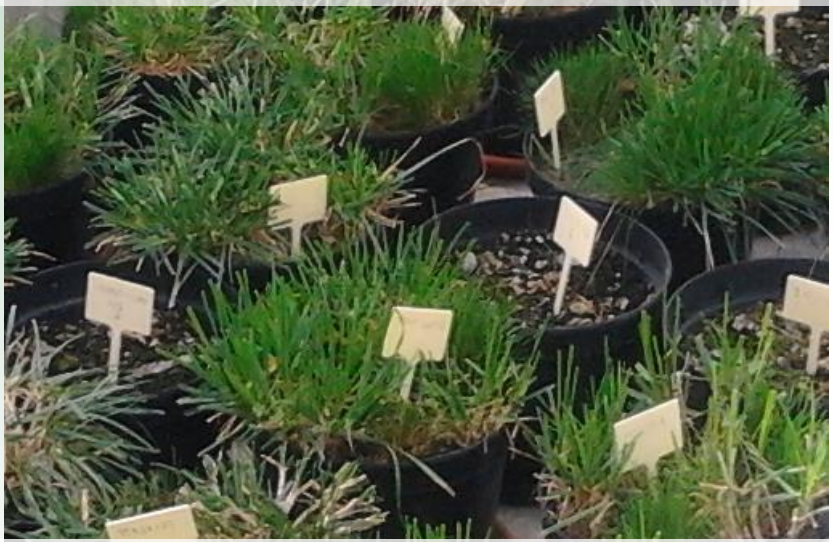




Effect of various combinations of soil treatment on amount of 4 PAHs added to soil determined 12 months later

Plants species:

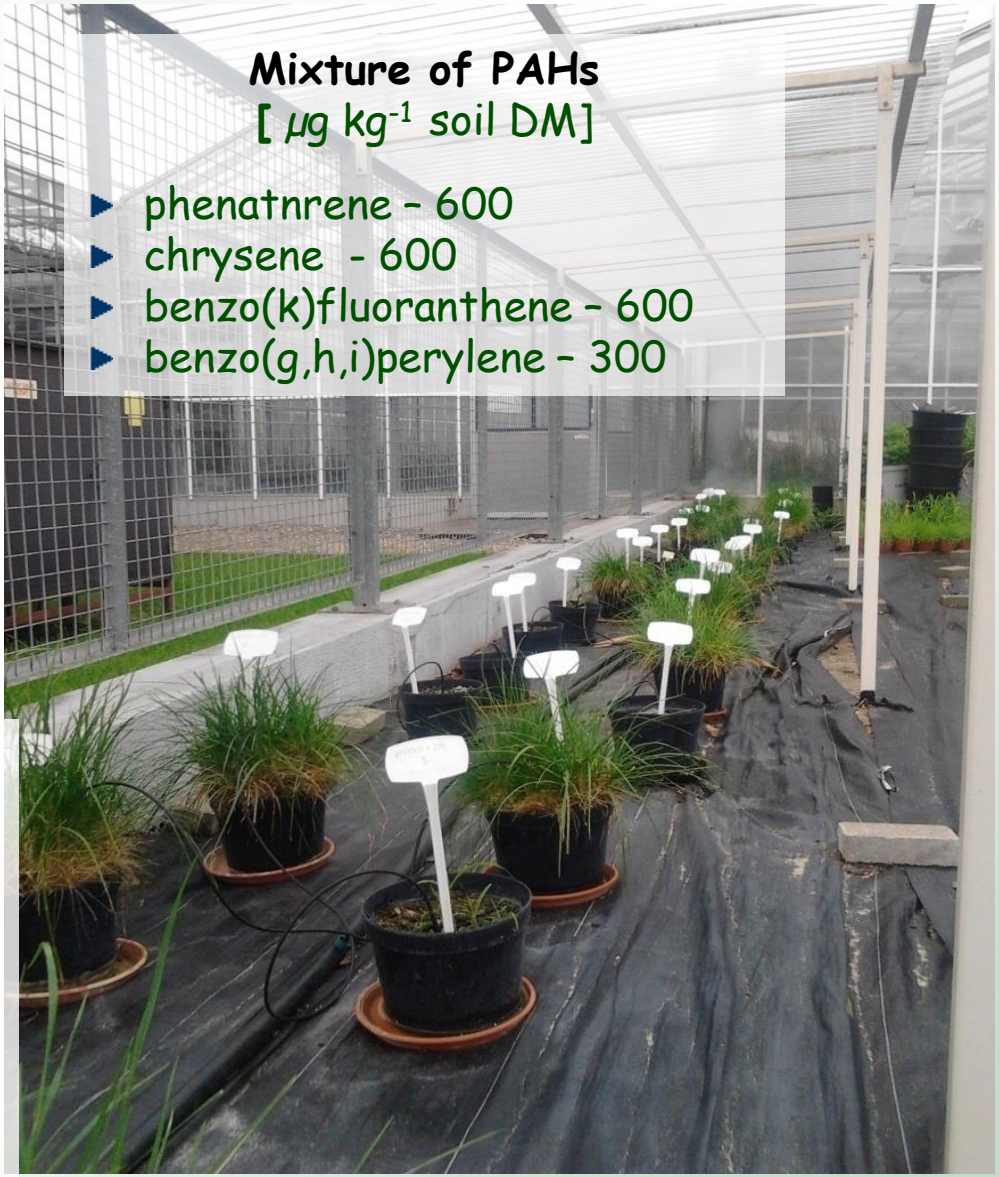
- perennial ryegrass (*Lolium perenne* 'Solen')
- red fescue (*Festuca rubra* Nimba')



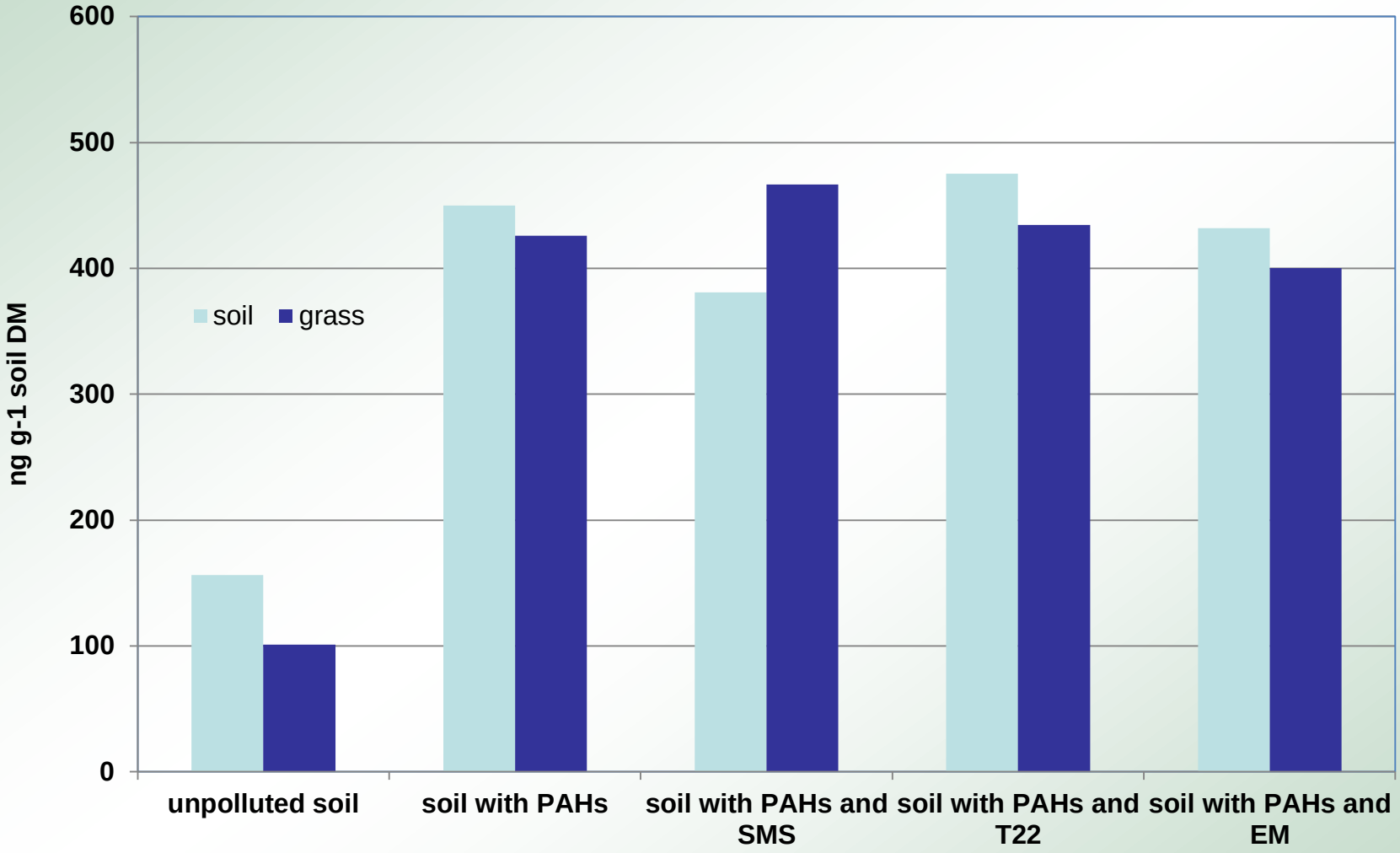
- Soil with or without grass (six plants per pot)
- Inoculation with
  - Spent mushroom substrate (SMS) - rye straw used to produce fruiting bodies of oyster mushroom
  - *Tirhoderma harzianum* T22 (T22)
  - Effective microorganisms (EM)

Mixture of PAHs
[$\mu g\ kg^{-1}$ soil DM]

- phenatnrene – 600
- chrysene - 600
- benzo(k)fluoranthene – 600
- benzo(g,h,i)perylene – 300



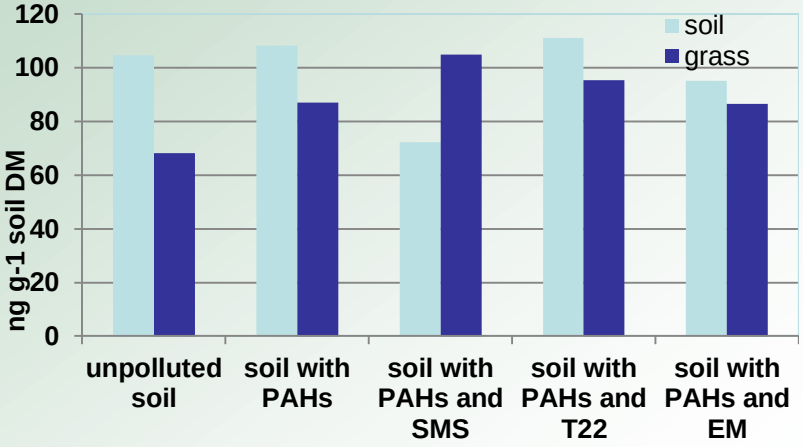
Effect of various soil treatments on amount of 4 PAHs added to soil determined 12 months later



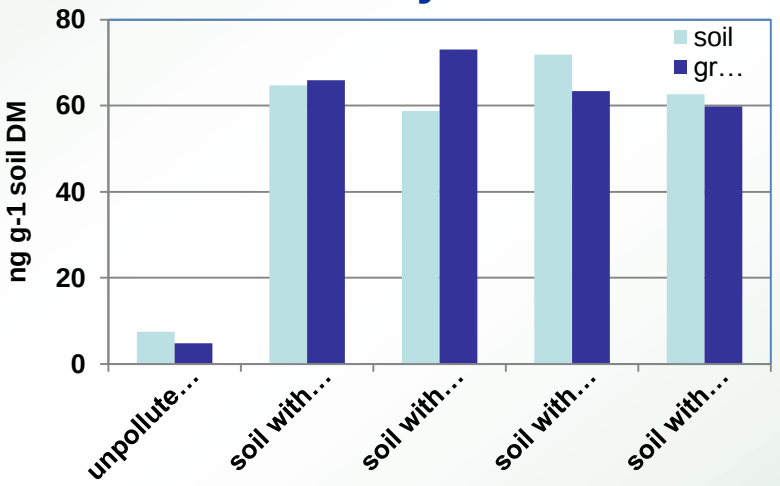
Unpolluted soil = no added PAH

Effect of various soil treatments on amount of 4 PAHs added to soil determined 12 months later

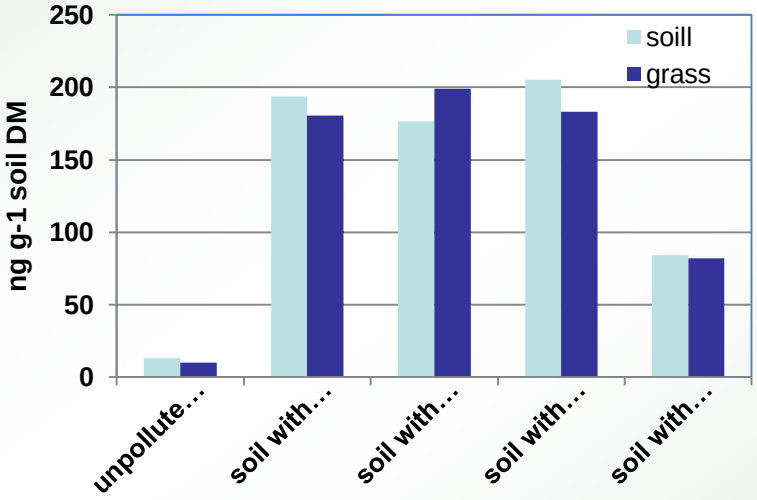
Phenatrene



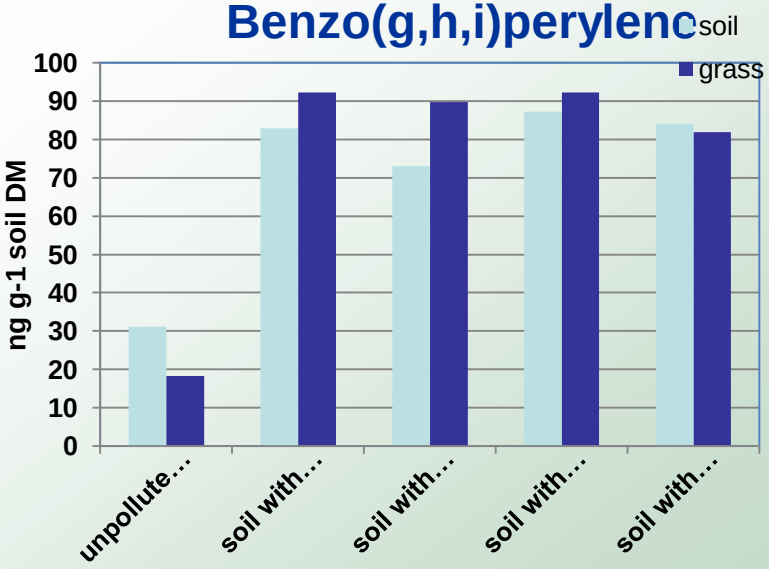
Chrysene



Benzo(k)fluoranthene



Benzo(g,h,i)perylene



CONCLUDING REMARKS:

- Amount of PAHs accumulated in plant leaves is greater in locations of higher level of air pollution
- Leaves accumulate more PAHs than twigs
- Plant species differ in amount of accumulated PAHs
- In urban areas phenantrene is major component of all 16 analyzed PAHs
- PAHs deposited in soil are degraded slowly and its improvement is very challenging