Capability of Urban Woody Plants to Reduce Particulate Matter Content in Tehran: A Country Report

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INTRODUCTION

✓ Climate change and urbanization: major challenges worldwide

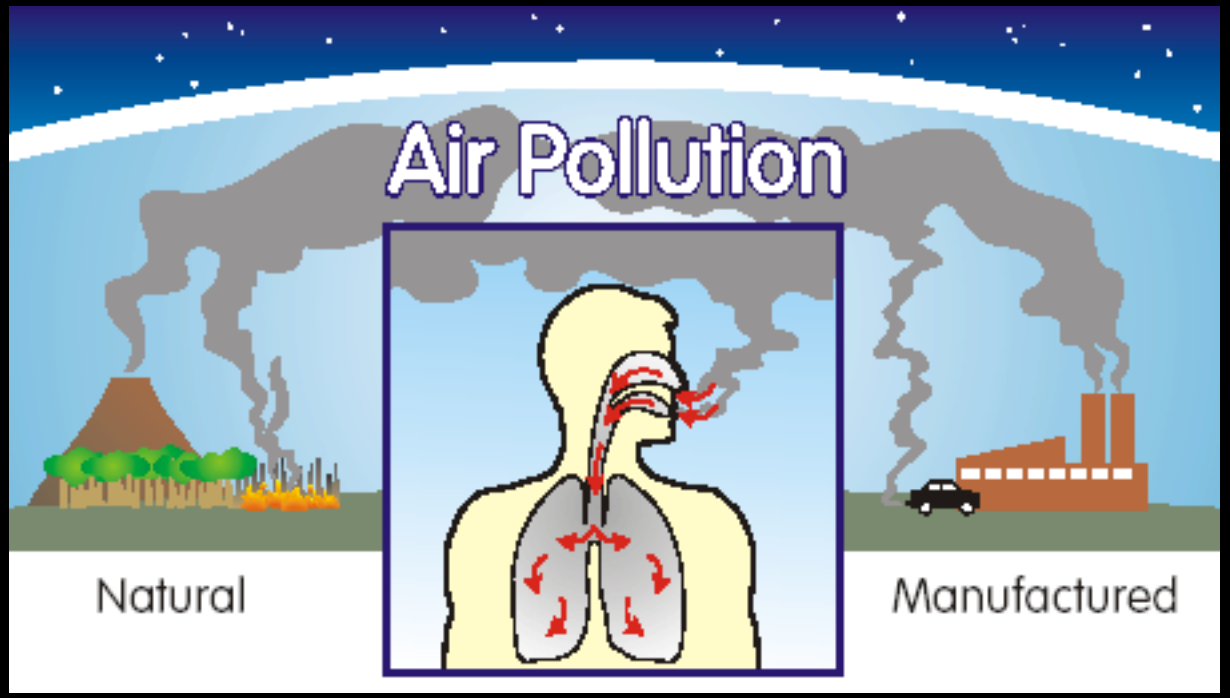
Both contribute substantially to air pollution in urban areas

✓ It is estimated that urban population increase to 8.5 billion by 2040

✓ Iran urban population: 31% in 1980 vs. 70% in 2010

✓ Tehran is one of the most populated cities in the world

Air pollution has medical and economic consequences



Policy makers has to find preferentially environmental friendly methods to reduce air pollution especially in urban areas

LITERATURE REVIEW

- Urban vegetation affects air quality through influencing pollutant deposition and dispersion

- There is an urgent need for experimental data including species evaluation and cultivation pattern data (Andersson-Sköld et al., 2015; Litschke and Kuttler, 2008; Petroff et al., 2008; Wolch et al., 2014)

OBJECTIVES

- ✓ Compare capability of the most common woody taxa in Tehran to reduce particulate pollution
- ✓ Find some influencing factors affecting particulate matter deposition by urban vegetation

METHODOLOGY

- ✓ Ten air quality monitoring stations were selected (based on data completeness)
- ✓ Individual trees were selected and their leaves were collected during vegetative season 2013 before rain season.
- ✓ For each species, five individuals were sampled in each station.
- ✓ To reduce location effect, 10 leaf samples were collected from different parts of each individual tree. Some leaf samples was kept aside because of their abnormal shape or fungal infection.

Platanus

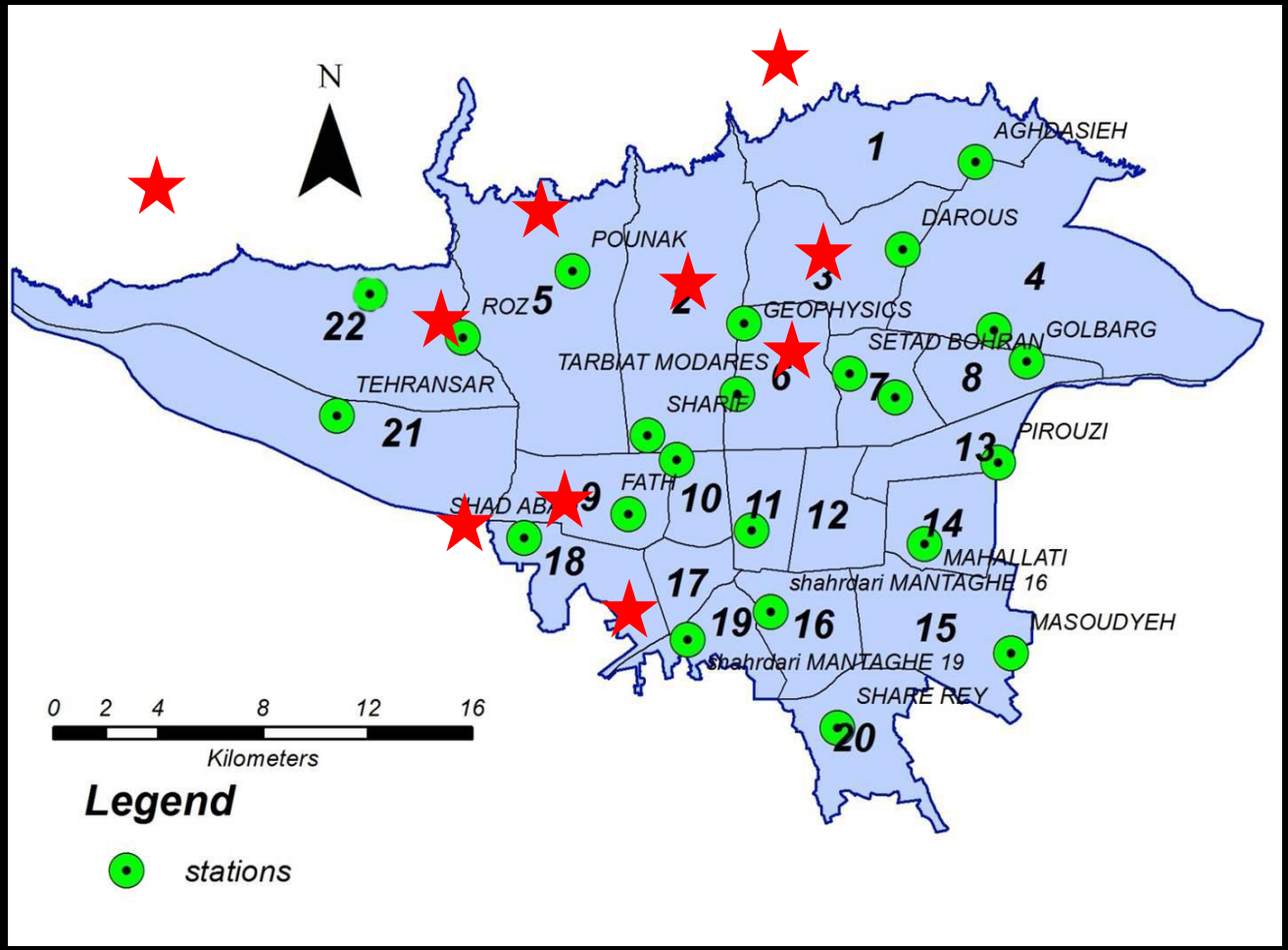
Ulmus

Pinus

Morus

Cedrus

Air Pollution Monitoring Stations in Tehran



PM measurement

Filters were dried for one hour in drying chamber

They were weighted using a Sartorius CPA2P micro-balance

Each leaf sample was placed in a glass container with 250 mL water and agitated for 100 seconds

Using a metal sieve with a mesh diameter 100 μm, particles larger than 100 μm were eliminated

Water was filtered by Whatman paper filters Type 91 (retention 10 μm) and next on Type 42 (retention 2.5 μm) using a vacuum pump

Filters were then dried and post-weighed (in Microgram) with the same procedure as in pre-weighing to calculate the mass of PM in each sample (Dzier˙zanowski et al. 2011).

Leaf Area measurement

- ✓ Leaf images were prepared using Nikon D5200 WITH Nikon Micro Nikkor 40 mm
- ✓ Leaf Area of samples were measured using CompuEye Image Analysis Software.
- ✓ Particulate matter content of samples were represented as microgram per square centimeter.

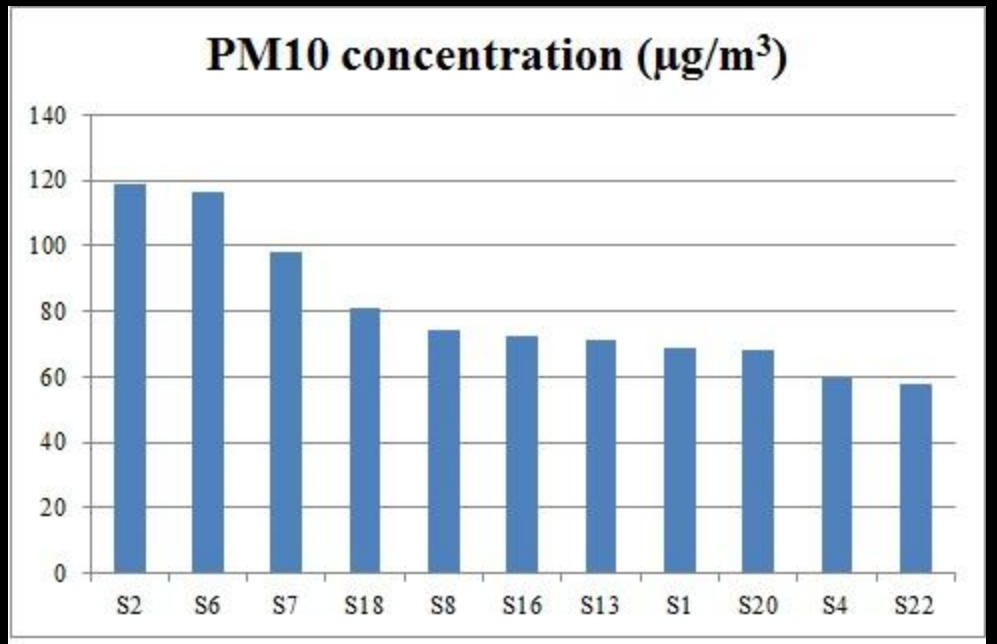
Statistical Analysis

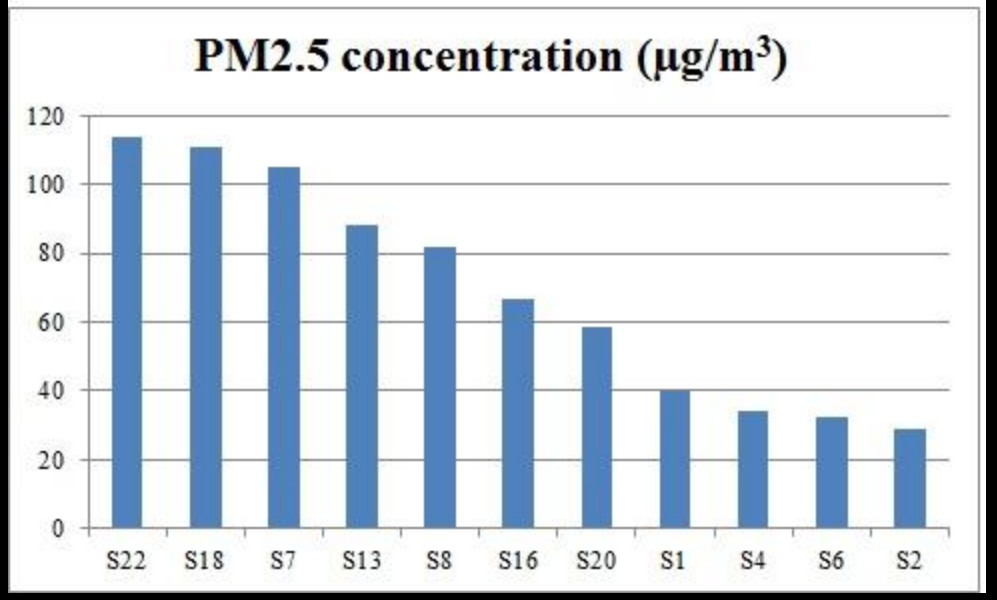
- ✓ Average PM content on leaves of woody taxa were compared among stations and among species
- ✓ Pearson correlation test was performed using SPSS 21.0 (IBM, USA)
- ✓ Significance of differences between mean values were tested using T-test

RESULTS

Stations

- Particulate matter concentrations for 3 months duration were averaged for each station
- We observed considerable difference
- Maximum and minimum PM10 concentrations were observed in S2 and S22 respectively
- Maximum and minimum PM2.5 concentrations showed exactly reverse pattern (Max in S22 and Min in S2)

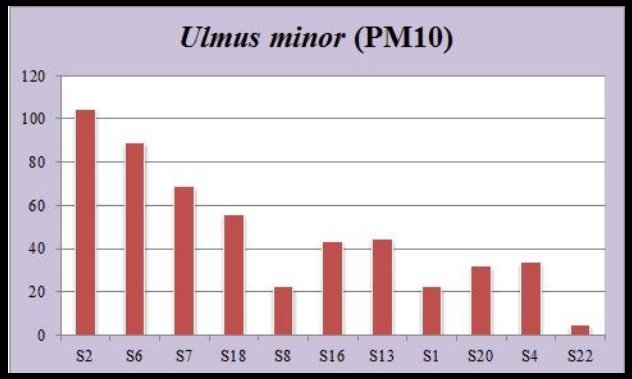


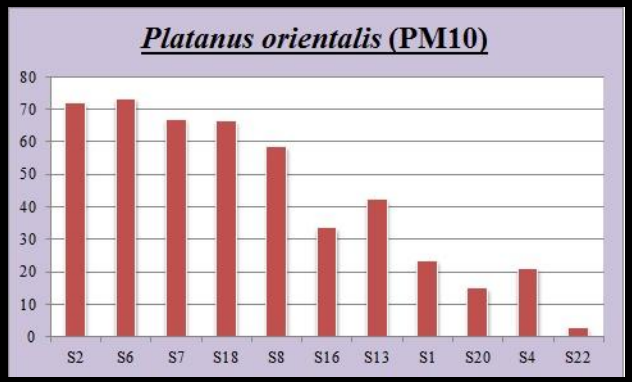


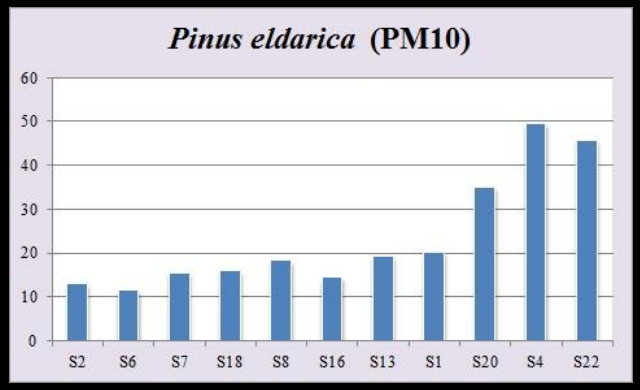
PM10

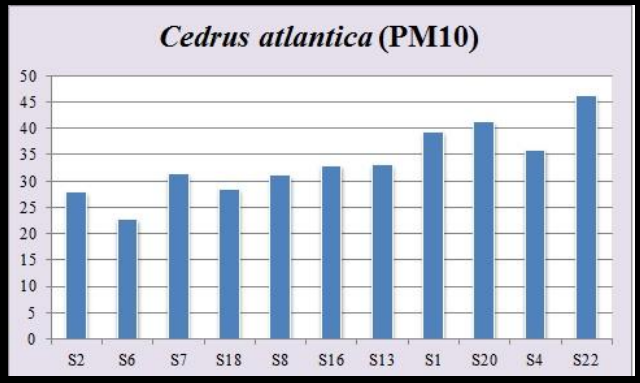
- Woody species showed remarkable ability to capture PM10 particles
- *Ulmus minor* was the most effective species
- *Pinus eldarica* showed less ability to capture PM10 particles

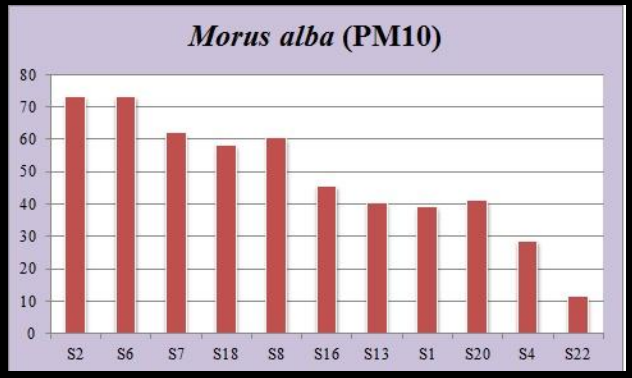
- PM10 content of leaf surface of deciduous taxa represent positive correlation with PM10 amount recorded in the air
- In contrast, evergreen needle leaved taxa captured more PM10 particles in less polluted stations







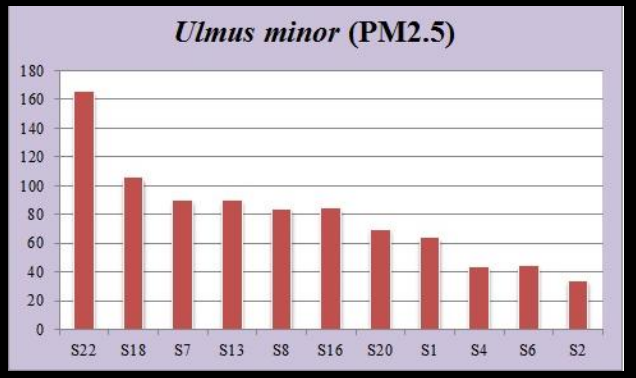


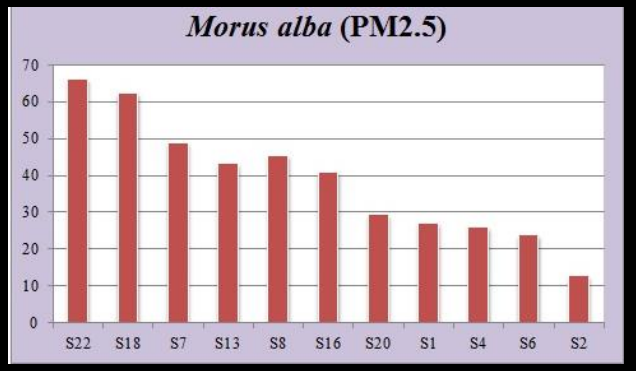


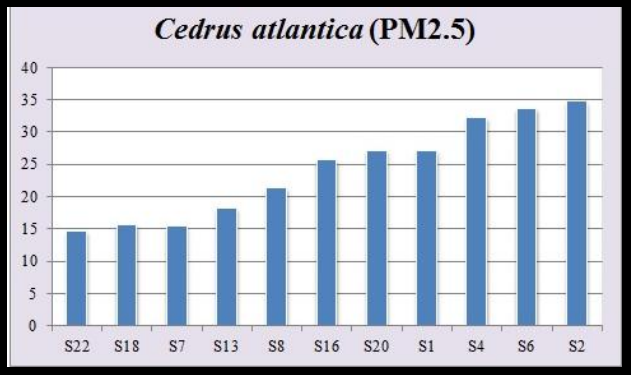
PM2.5

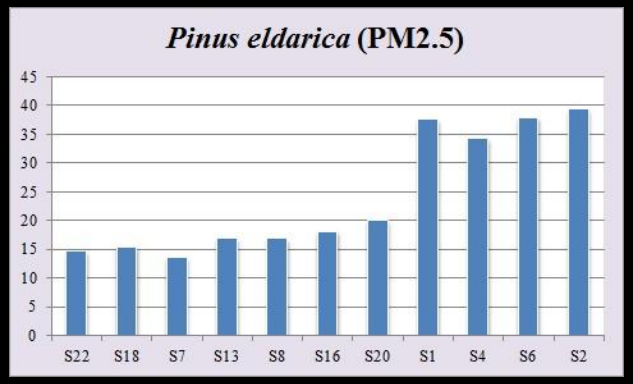
- Quantity of PM2.5 differed between the species
- *Ulmus minor* was the most effective species
- *Cedrus atlantica* showed less ability to capture PM2.5 particles

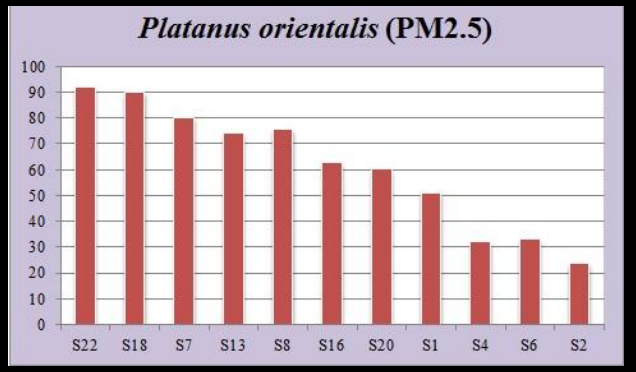
- PM2.5 content of leaf surface of deciduous and evergreen taxa represent a positive and negative correlations respectively with recorded PM2.5 concentrations in the air (as for PM10)











Pearson Correlation

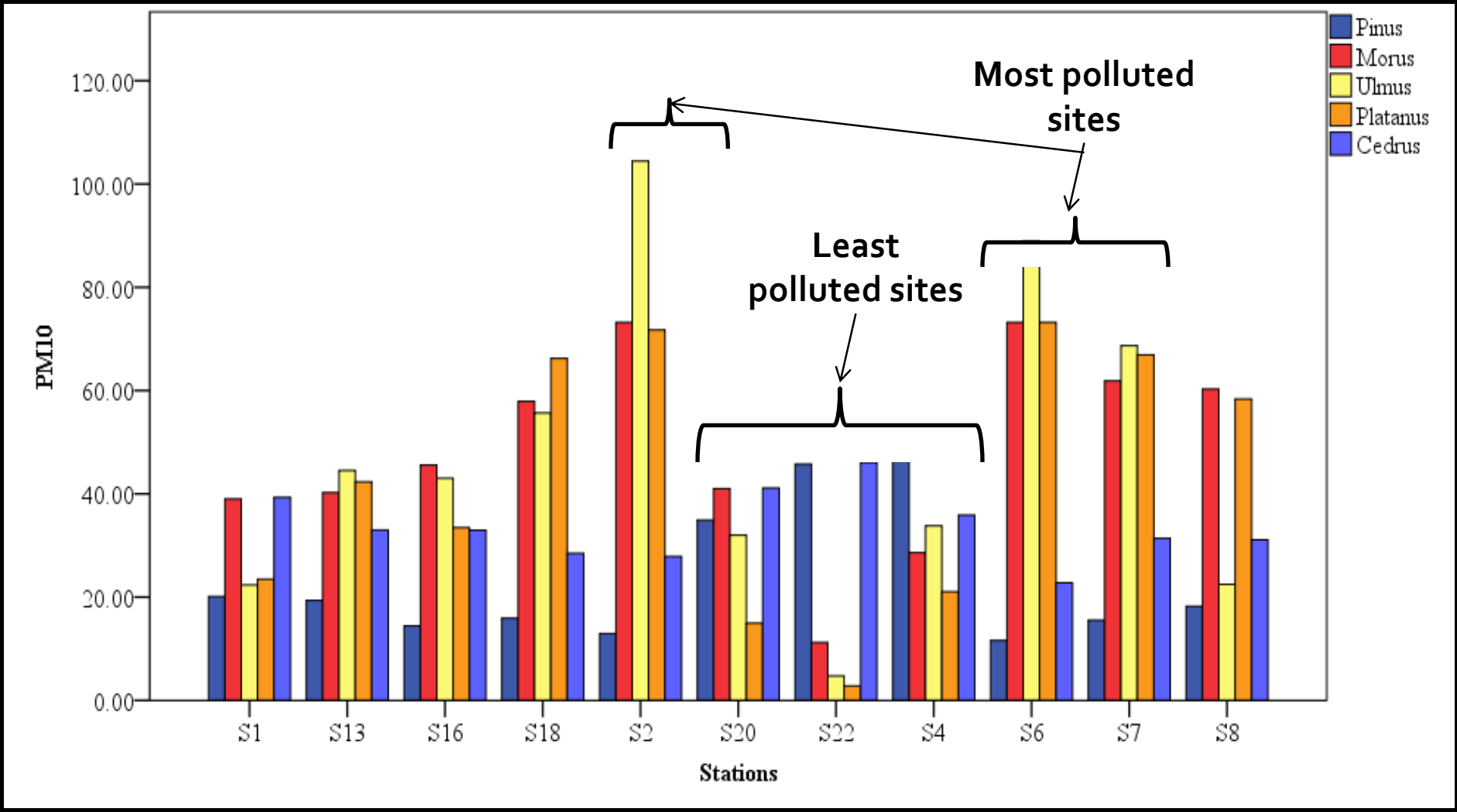
		Pinus	*Morus*	*Ulmus*	*Platanus*	*Cedrus*
PM10		-0.692	0.881	0.943	0.844	-0.791
	ρ-value	0.018	0.023	0.034	0.001	0.004
PM2.5		-0.917	0.959	0.879	0.877	-0.880
	ρ-value	0.011	0.042	0.012	0.043	0.003

T-test statistics revealed significant difference among taxa within stations and for particle size fraction

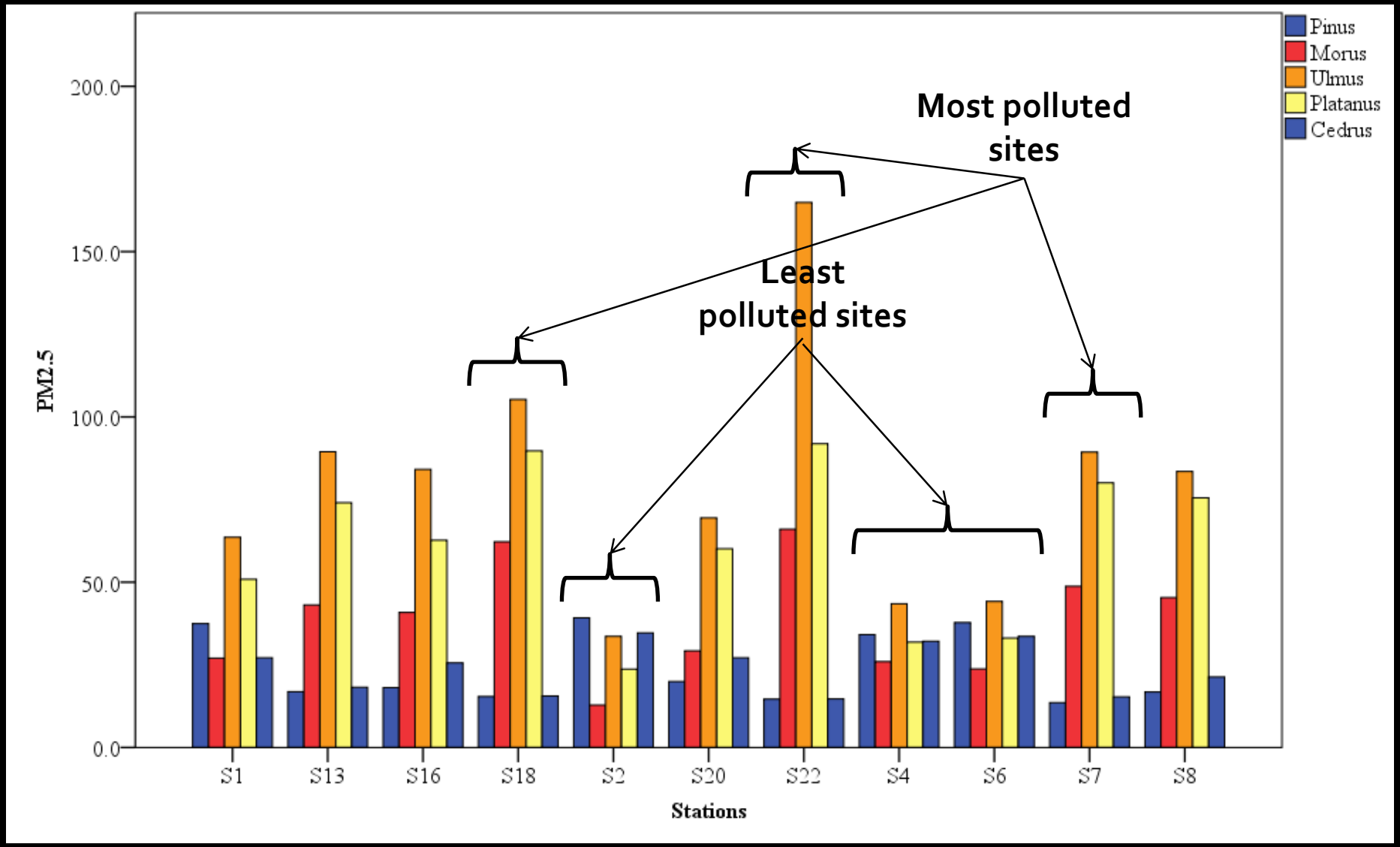
Evergreen taxa showed more efficiency in less polluted sites

Generally, woody taxa with rough surface of leaves, e.g. *Ulmus minor* captures more particles

Species differences



Species differences



Site differences

- Confirming findings by several studies (e.g. Dzierżanowski et al. 2011; Langner et al. 2011; Popek et al. 2011; Sæbø et al. 2012; Janhäll 2015; Mori et al. 2015) urban vegetation considerably reduces airborne particulate matter. Its efficiency is affected by different factors including site characteristics and species properties.

- Similar sites with different concentrations of a pollutant can be considered as sites at different distances from same pollution source.

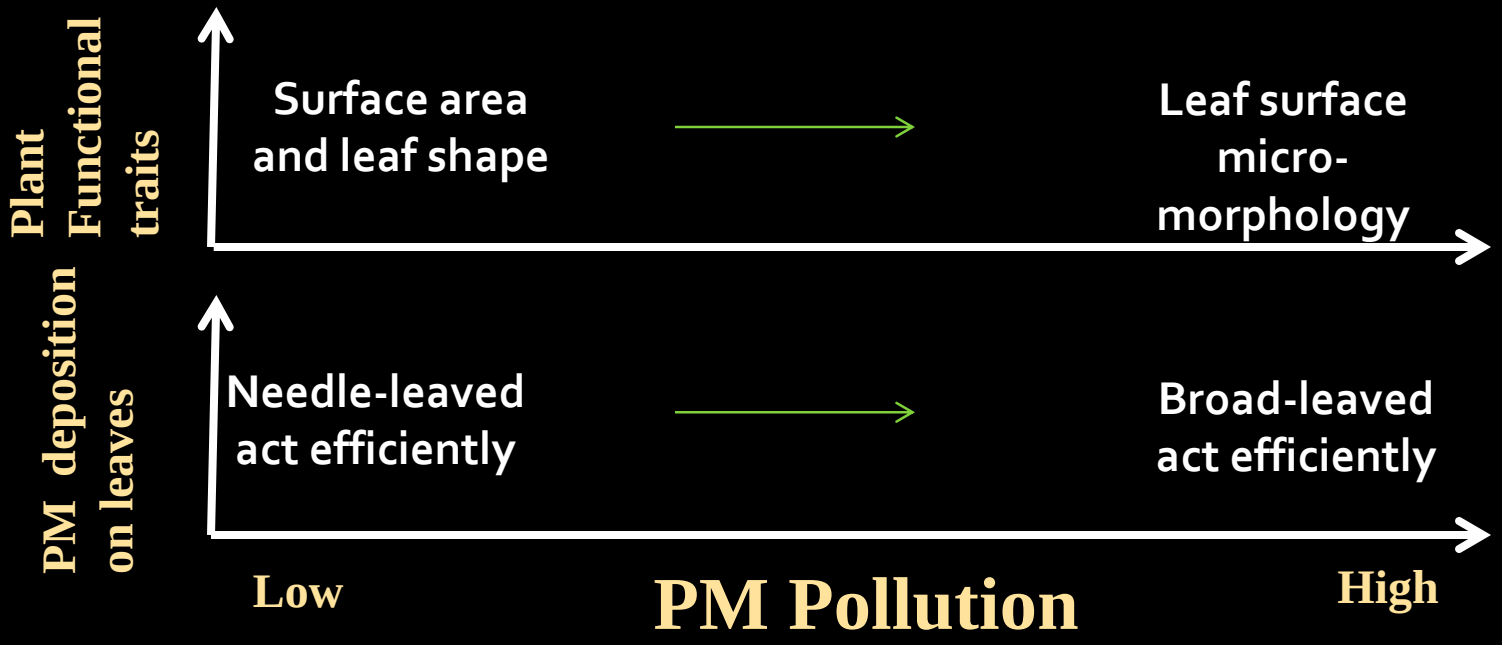
- As we expected (e.g. Litschke & Kuttler 2008), there was strong correlation between pollution level and deposition rate of particulate matter on the leaf surface. However, type of correlation depends on the plant species and pollution level.

Species differences

- Broad-leaved taxa; compared to needle-leaved plants, showed higher ability to capture particulate matter (PM10 and PM2.5) on their foliage (confirming McDonald et al. 2007) in most polluted sites (in agreement with Freer-Smith et al. 1996, 2005; Przybysz et al. 2014) probably due to their higher surface area
- Interestingly, PM10 and PM2.5 deposition level on needle leaved taxa increased with decreasing pollutant concentration of the site
- Probably, leaf surface micro-morphology (roughness, trichomes, epicuticular wax) play more important role with increasing pollution level. Moreover, conifers are less tolerant to high pollution level (Dzierżanowski et al. 2011).

CONCLUSION

- Broad-leaved taxa with rough surface (*Ulmus* sp.) efficiently capture airborne particulate matters (e.g. Becket et al. 2008).
- Apparently, the importance of plant functional traits differ by site characteristics
- The pollution level of the sites has direct effects on the rate of PM deposition on leaves.



Thanks for your kind attention