National Research Council

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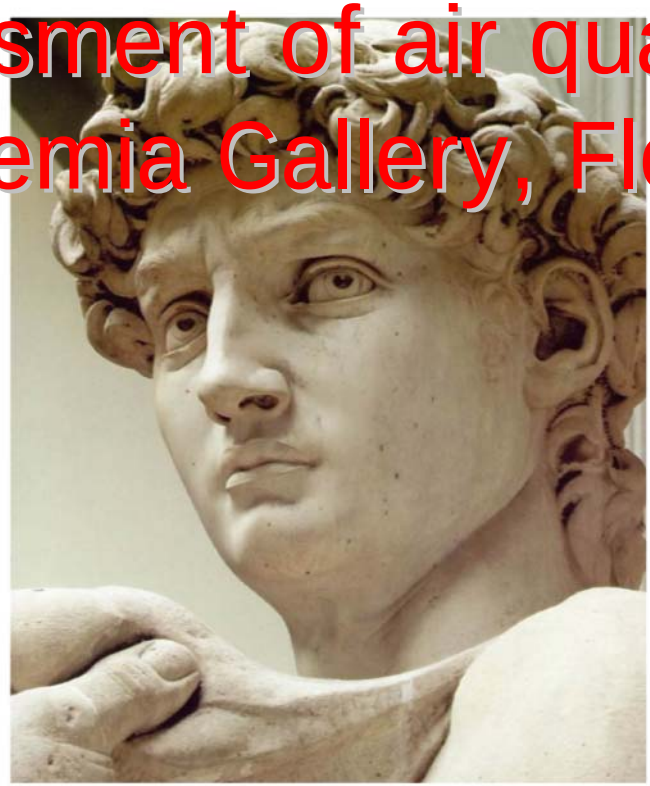
Institute of Atmospheric Pollution Research

The assessment of air quality at the Accademia Gallery, Florence



Francesca Vichi

IAQ in museums and archives

9th Indoor Air Quality Meeting
Chalon sur Saône 21st–23rd of April 2010

Aim of the study

- Assessing of the air quality in different locations of the first floor where the statue is displayed;
- Testing the performances of HVAC (heating, ventilation, air conditioning system);
- Testing the effect of the public on the air quality inside the Gallery.

Outline of the study

- ✓ Three months of measurements of gaseous pollutants (for each of two consecutive years)
- ✓ Six weeks of measurements of particles (during the following year)
- ✓ One intensive campaign of measurement of particles (lasting two days)

- ✓Measurements of gaseous pollutants at three internal sites;
- ✓Measurements of particles by gravimetry at two sites (one external and the other near the statue);
- ✓XRF determination of metallic components of PM10;
- ✓Intensive measurements of particles at different heights at three sampling points (right, left and in front of the statue) by nephelometry.

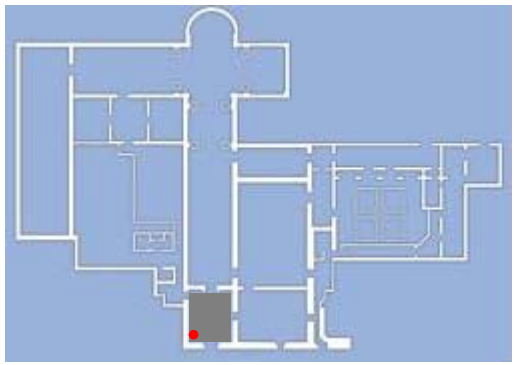
Criteria for conducting an assessment of air quality aimed at the protection of marble made works of art

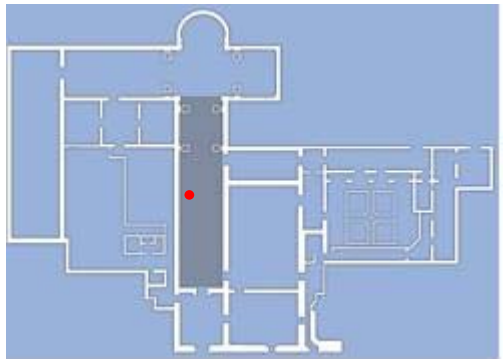
- Measure of pollutants affecting the conservation because of their harmful potential:
  SO_2 and other acidic gases for ex. HNO_3
  and
  Particles;

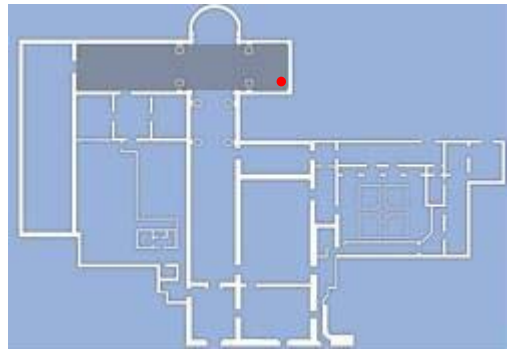
- Map of the exhibition place especially along the possible infiltration ways;

- Taking into account the presence of HVAC system test its performances on protection from external pollutants and check for possible inhomogeneities of the distribution of pollutants inside.

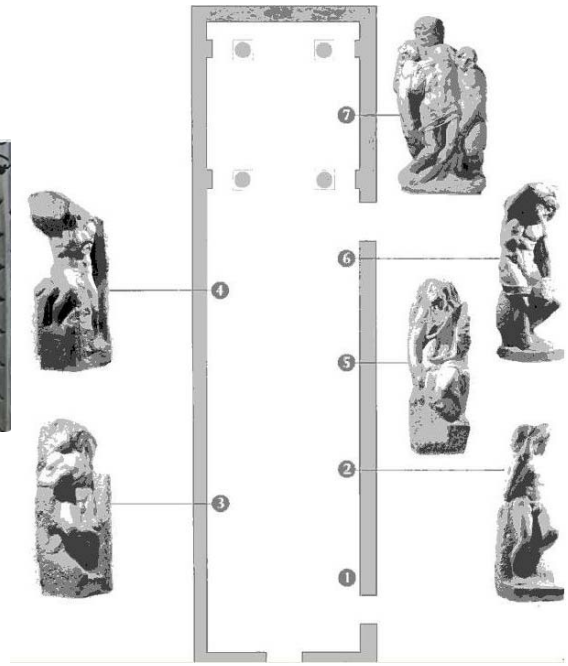
Monitoring gaseous pollutants



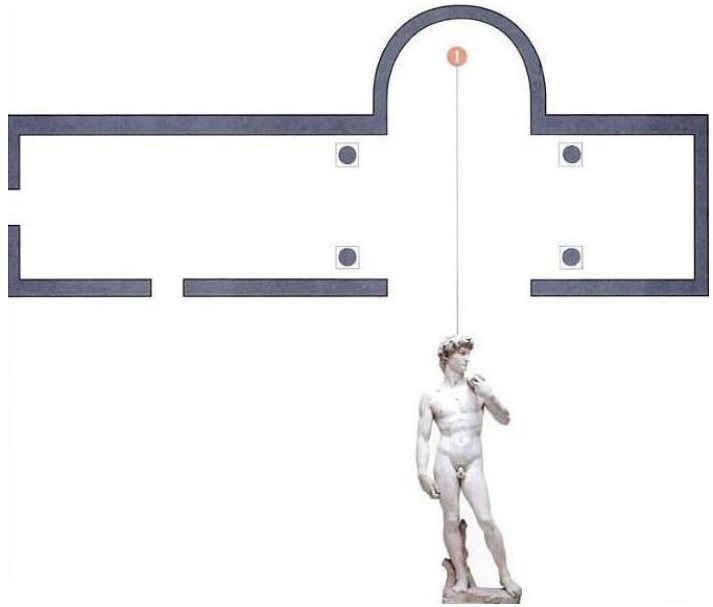




Entrance



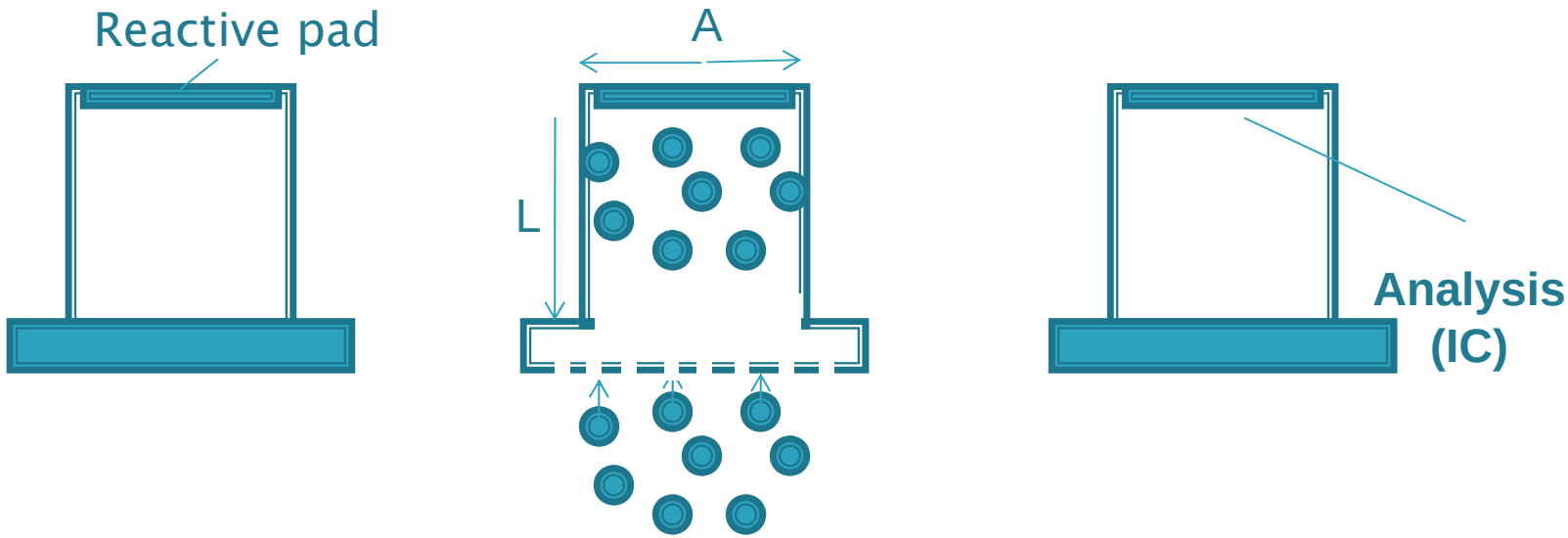
Prigioni's Gallery



Michelangelo's David Tribune

Monitoring gaseous pollutants

Working principle of Diffusive sampling



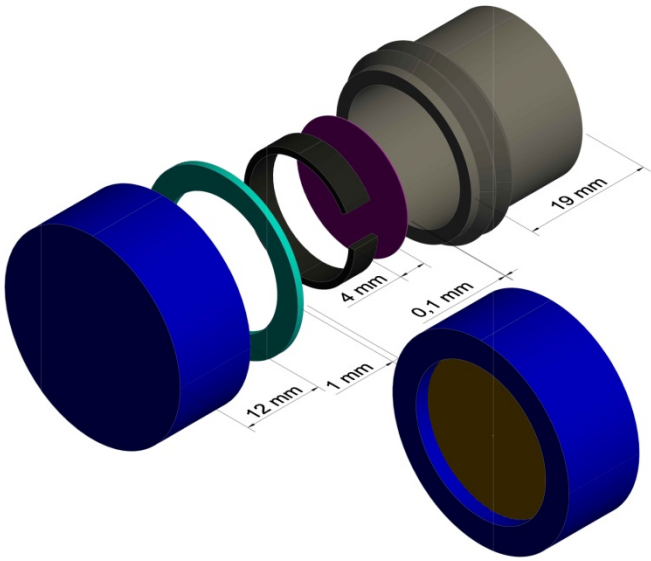
Fick's first law

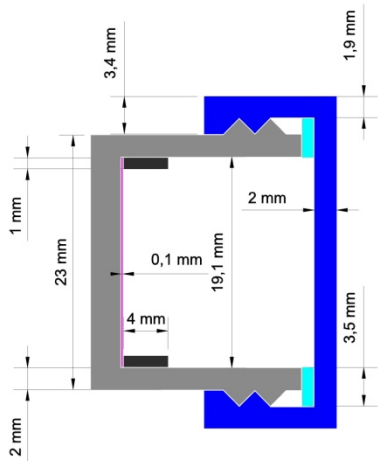
$$\Phi = -D\, dC/dx$$

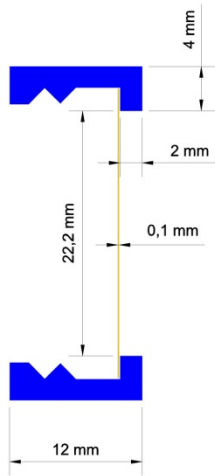
$$\Phi = S/A\, \Delta t$$

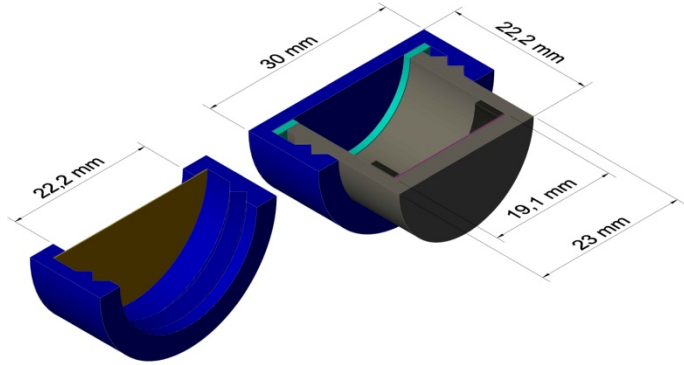
$$dC/dx = C_a - C_s$$

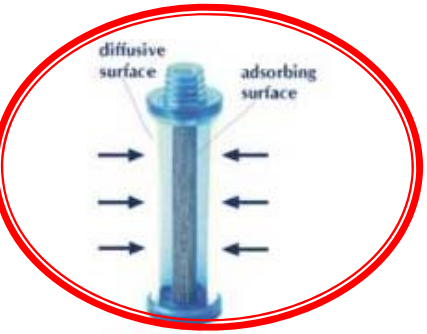
$$C_a = (S\, L\, /D\, A\, \Delta t) + C_s$$


19 mm
4 mm
0,1 mm
1 mm
12 mm


3,4 mm
1,9 mm
1 mm
23 mm
2 mm
0,1 mm
19,1 mm
4 mm
3,5 mm
2 mm

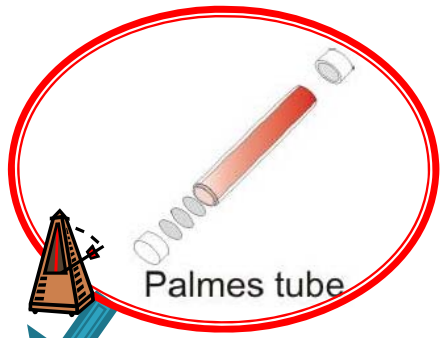

4 mm
2 mm
22,2 mm
0,1 mm
12 mm


30 mm
22,2 mm
22,2 mm
19,1 mm
23 mm

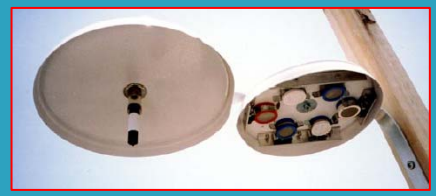


Radiello

Ogawa



Palmes tube

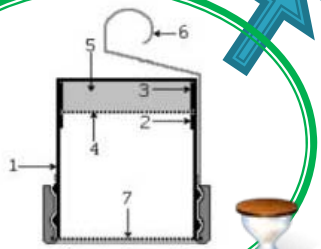


In the field

In museums

In libraries

Passam

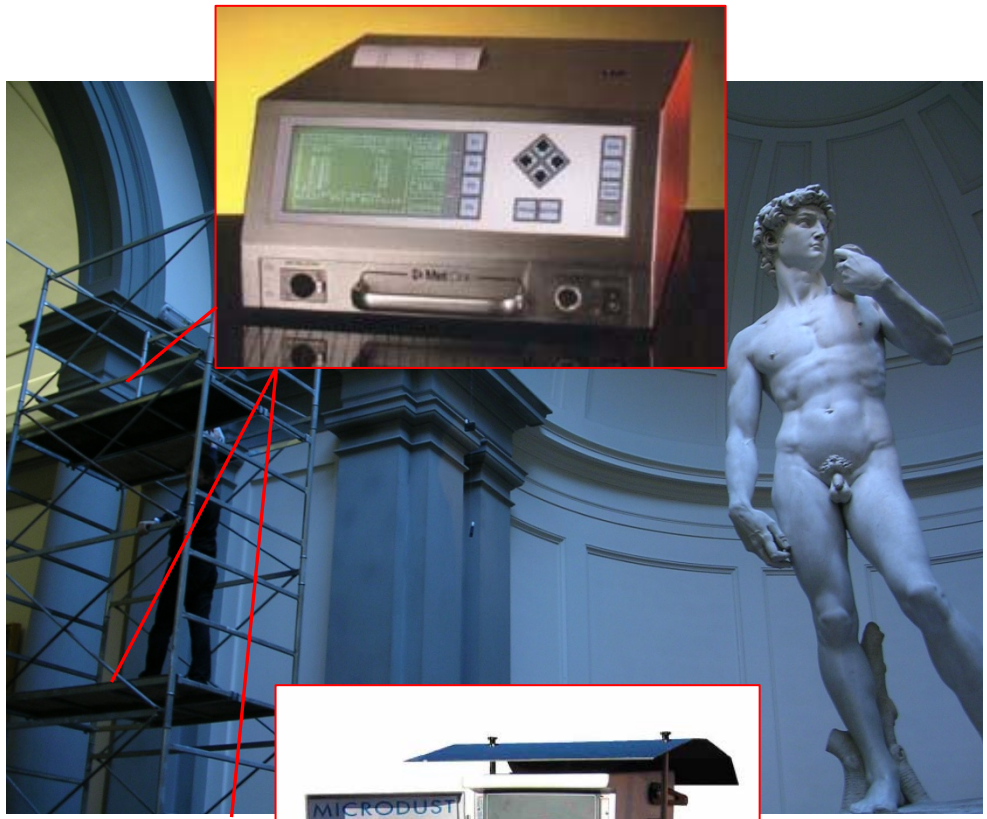


Analyst

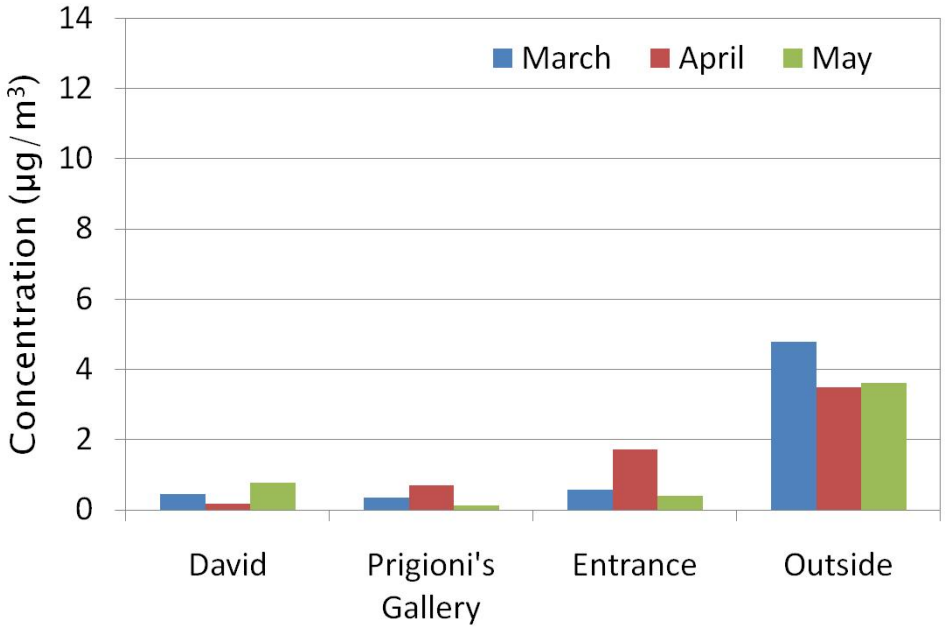
Short term measurements

Long term measurements

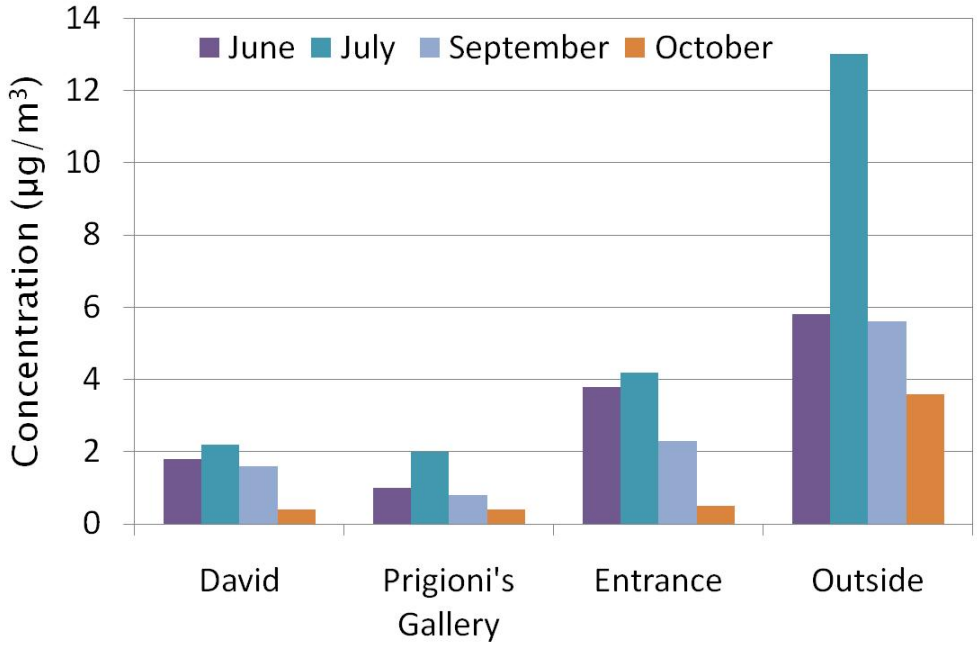
Monitoring particles



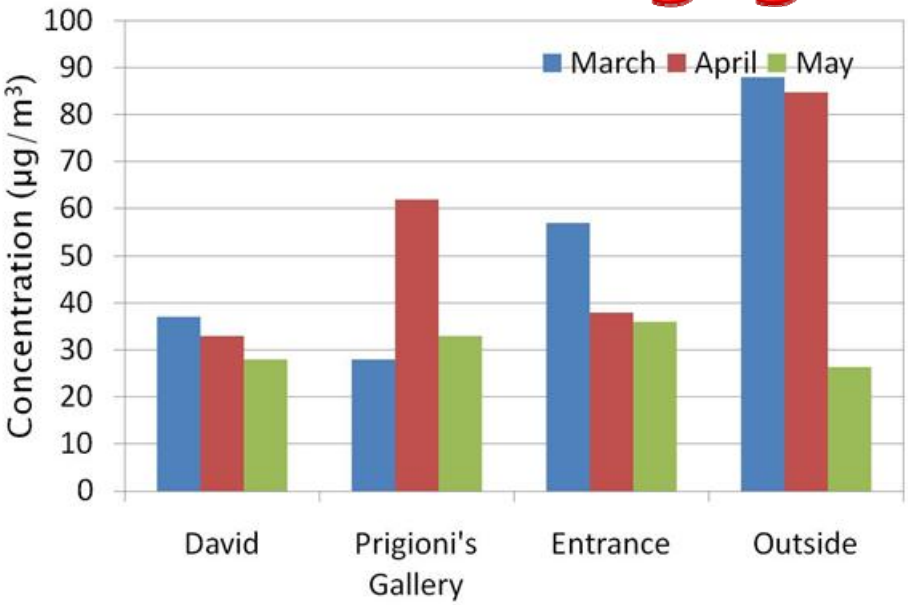
Monitoring gaseous pollutants



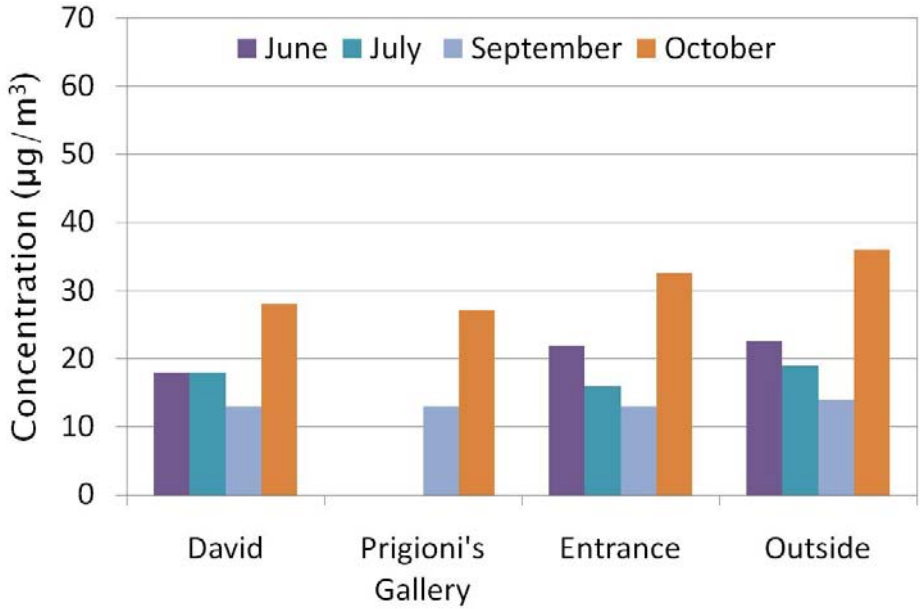
SO_2



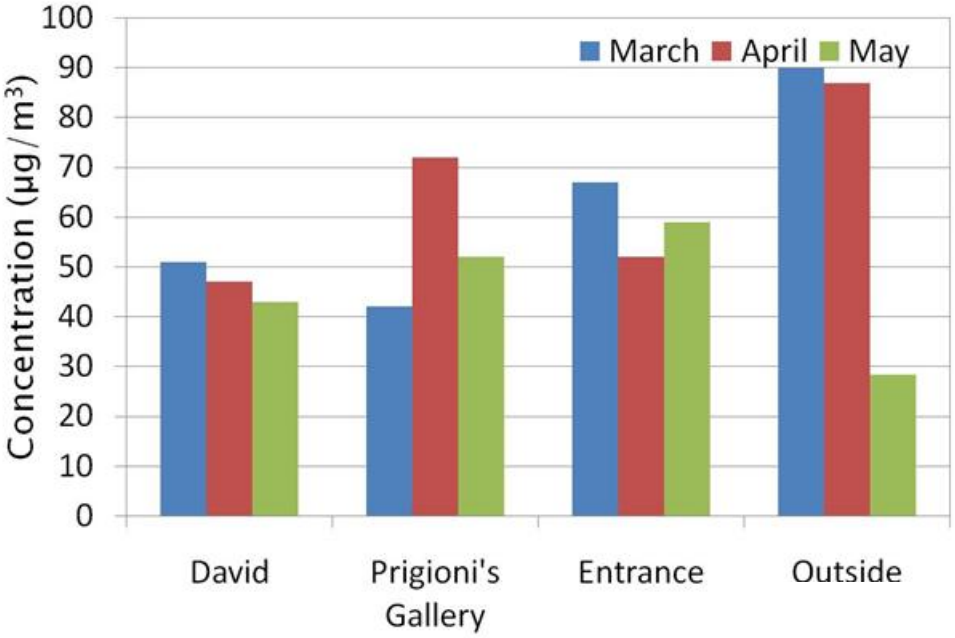
Monitoring gaseous pollutants



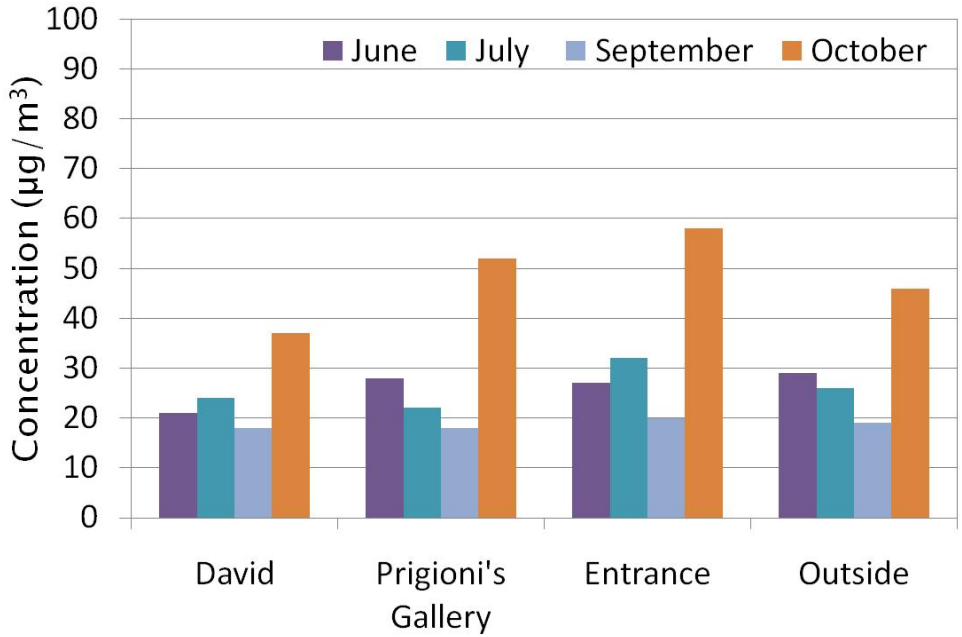
NO_2



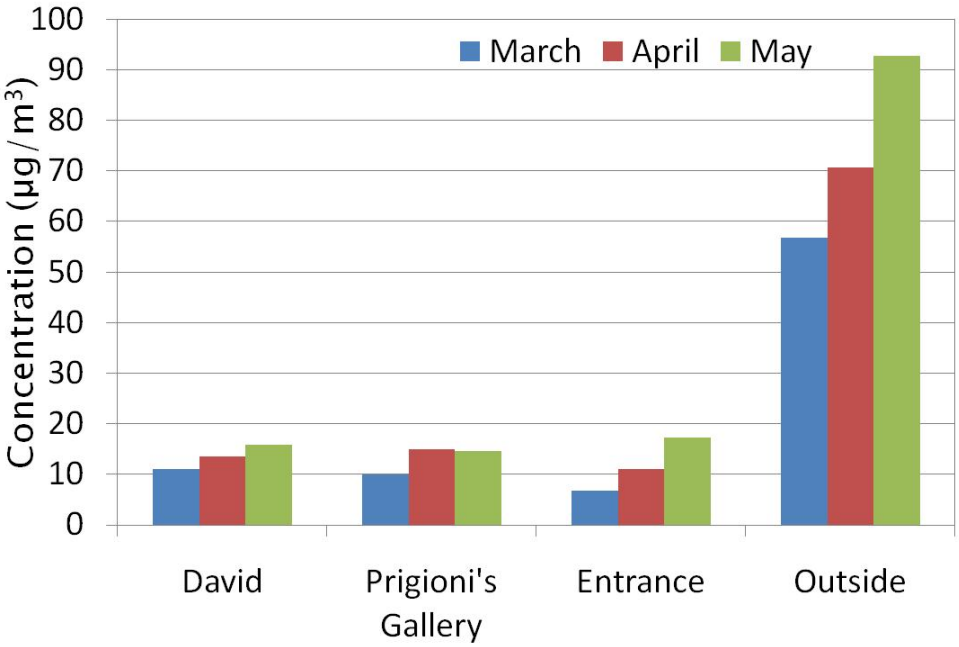
Monitoring gaseous pollutants



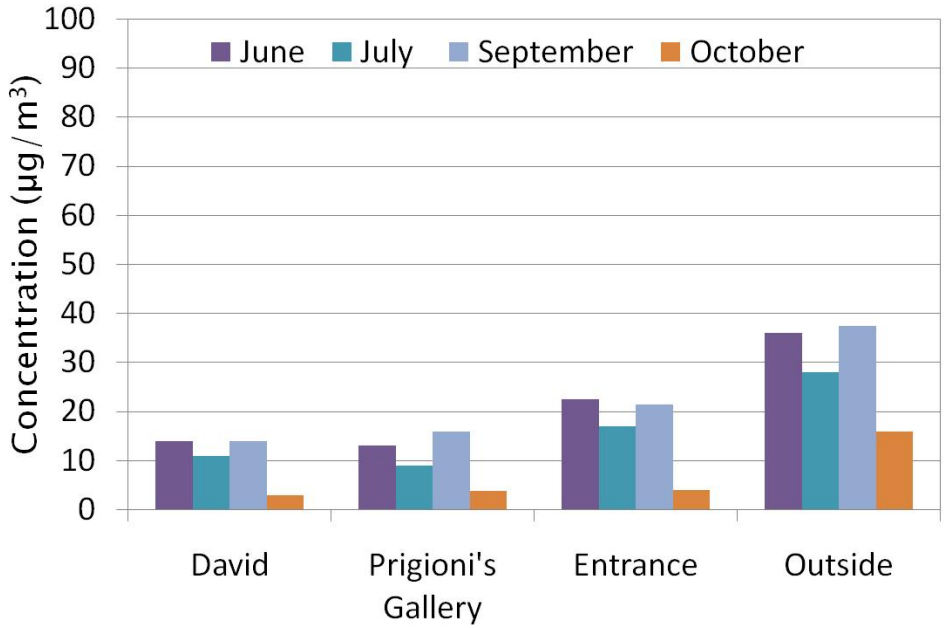
NO_x



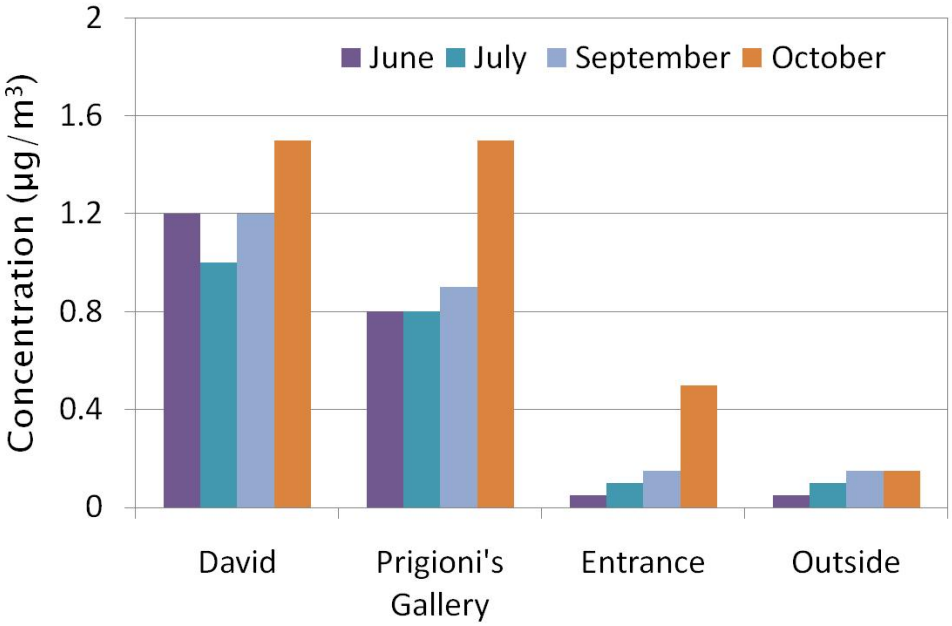
Monitoring gaseous pollutants



O_3

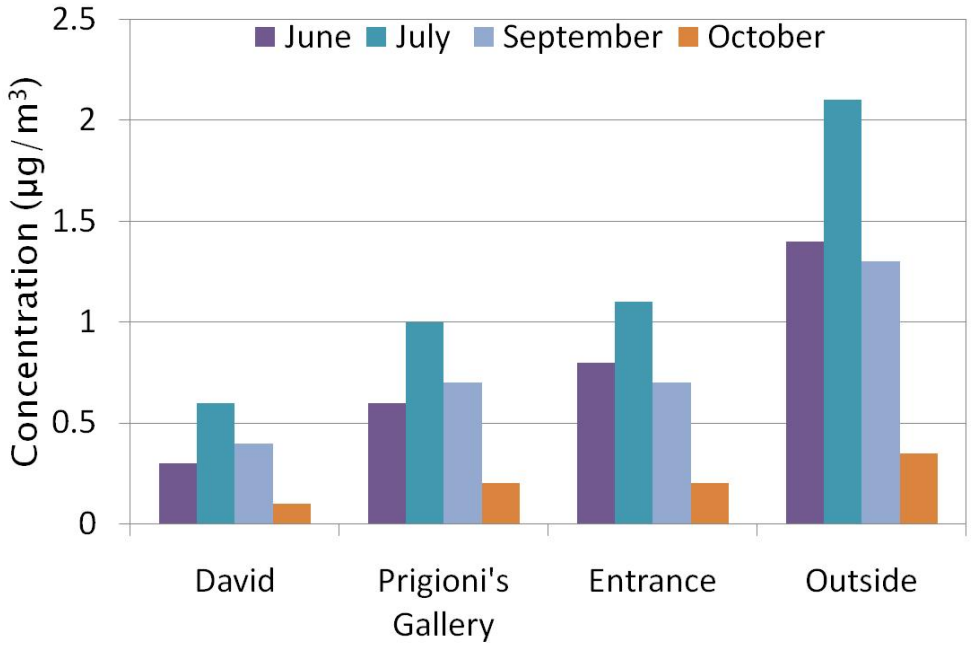


Monitoring gaseous pollutants



HNO_2

HNO_3



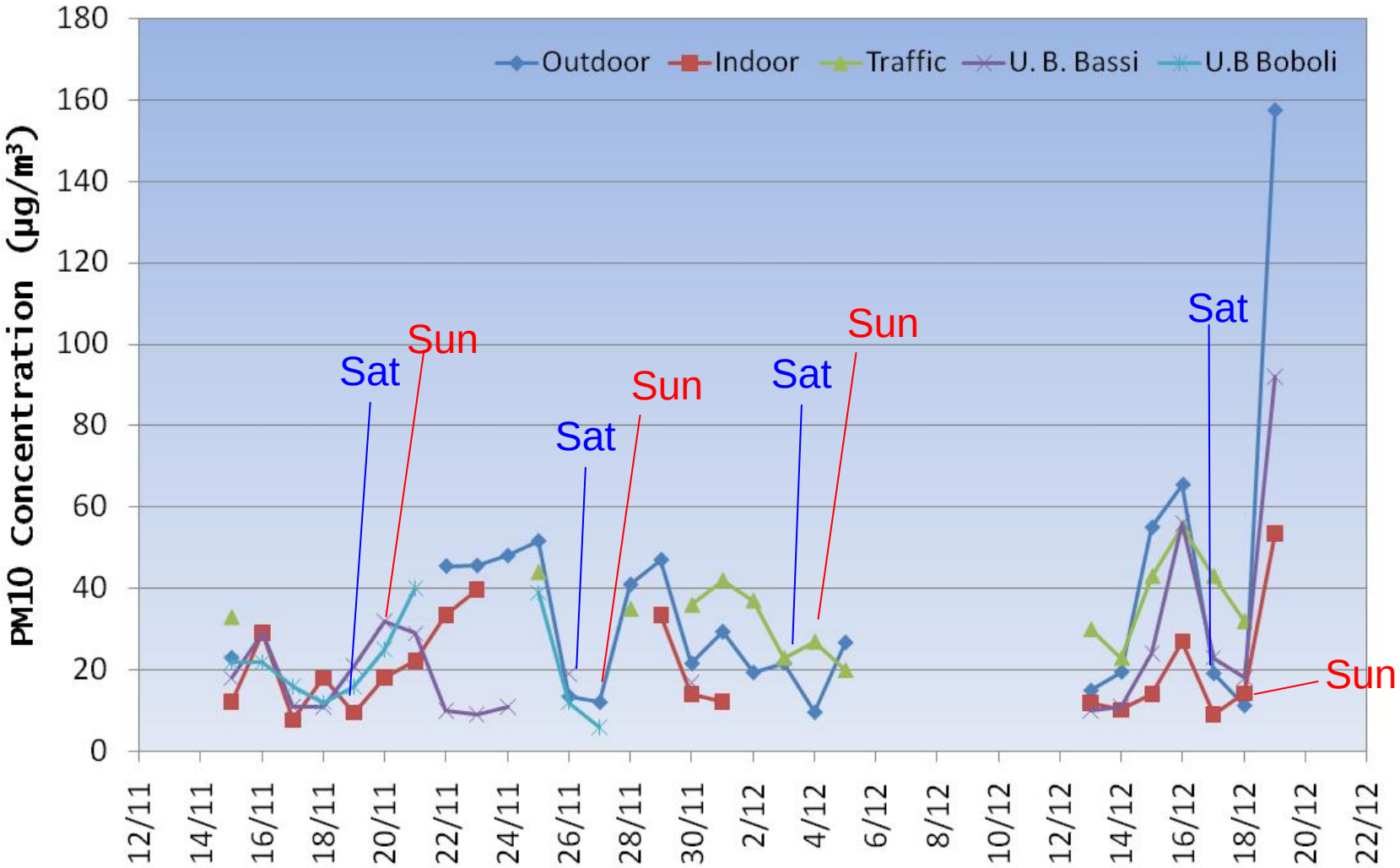
Evaluation of the influence of outside environment on indoor air quality

Compound	Indoor/Outdoor	Observations
Sulphur Dioxide	0.1–0.5	
Carbon Dioxide	1–3	
Carbon Monoxide	<1	No internal sources of CO
	1–5	With internal sources of CO
Nitrogen Dioxide	0.5–1	No internal sources of NO_2
	2–5	With internal sources of NO_2
Ozone	0.1–0.25	No internal sources of O_3
Particles	1	No smokers
	>2	Smokers
Radon	3–5	
Formaldehyde	10	
Aromatic Hydrocarbons	1–3	
Polyciclic Hydrocrbons	0.5	No smokers
Hydrocarbons	>1	Smokers

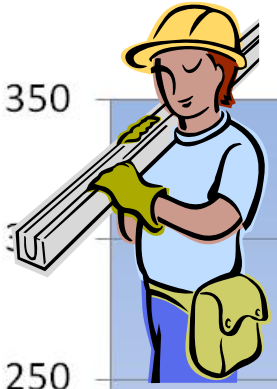
Indoor/Outdoor Ratio

	David (Tribune)	Uffizi/Leonardo (Room 15)	Uffizi/Dürer (Room 20)
NO_2	0.82	0.55	0.51
O_3	0.37	0.11	0.08
SO_2	0.20	0.16	0.12
HNO_3	0.27	0.21	0.06
NOx	0.85	0.84	0.89
HONO	6.03	8.02	12.03

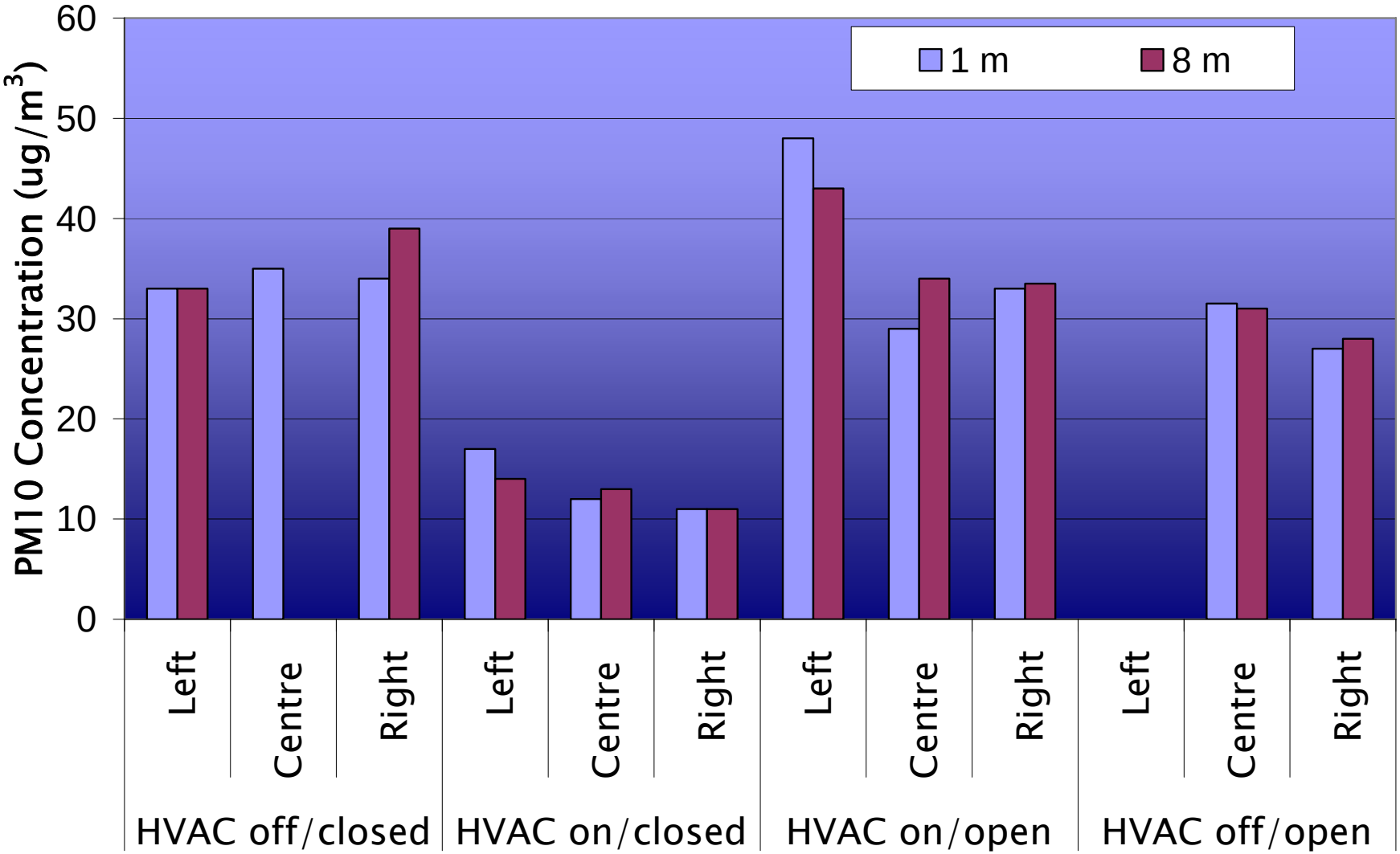
Gravimetric Measurements of PM10

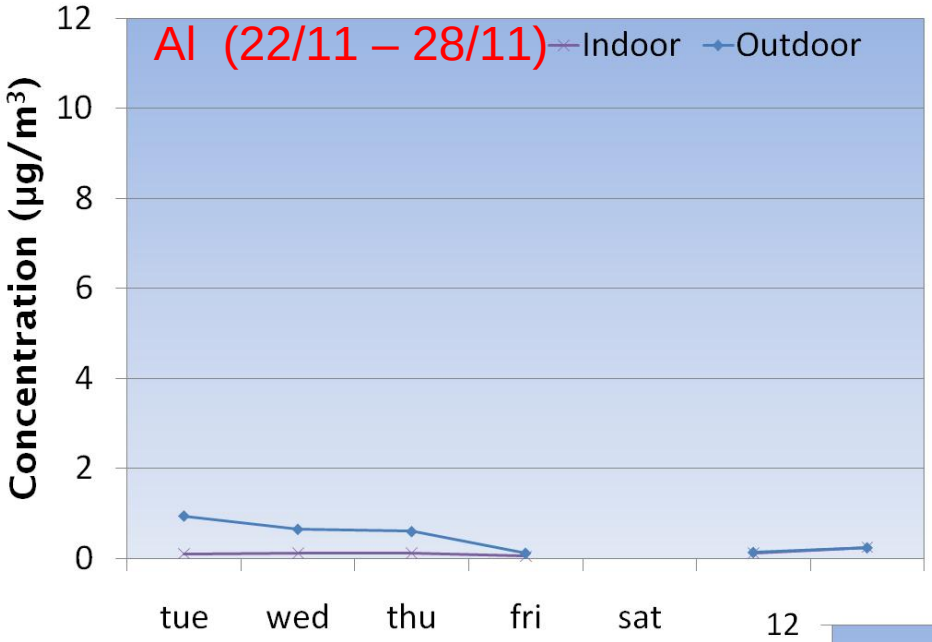


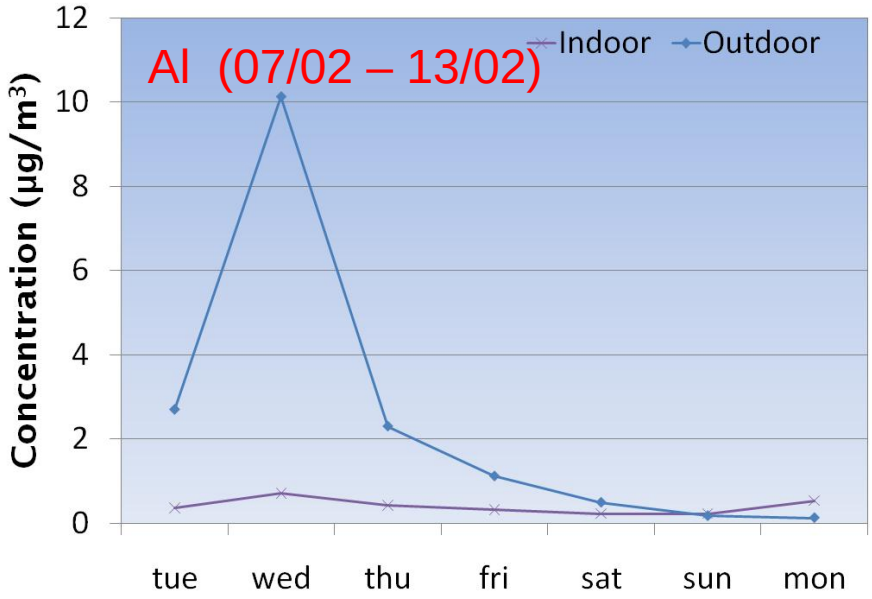
Gravimetric Measurements of PM10

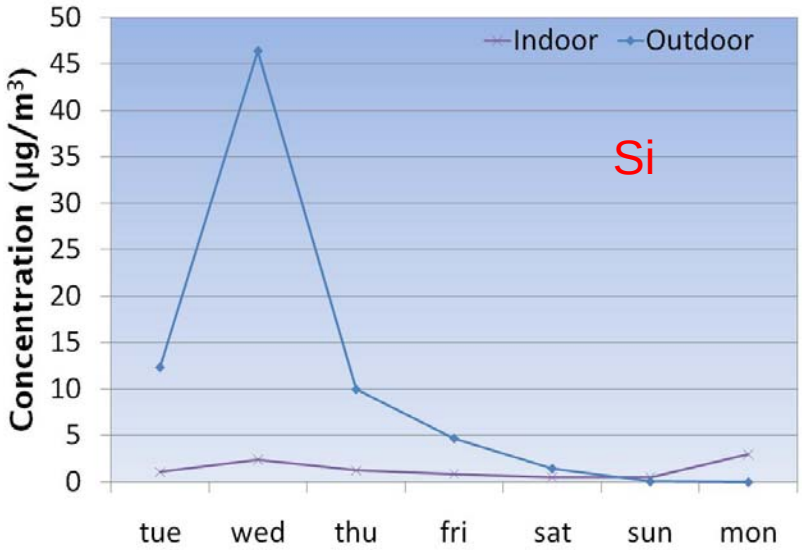


Nephelometric Measurements of PM10

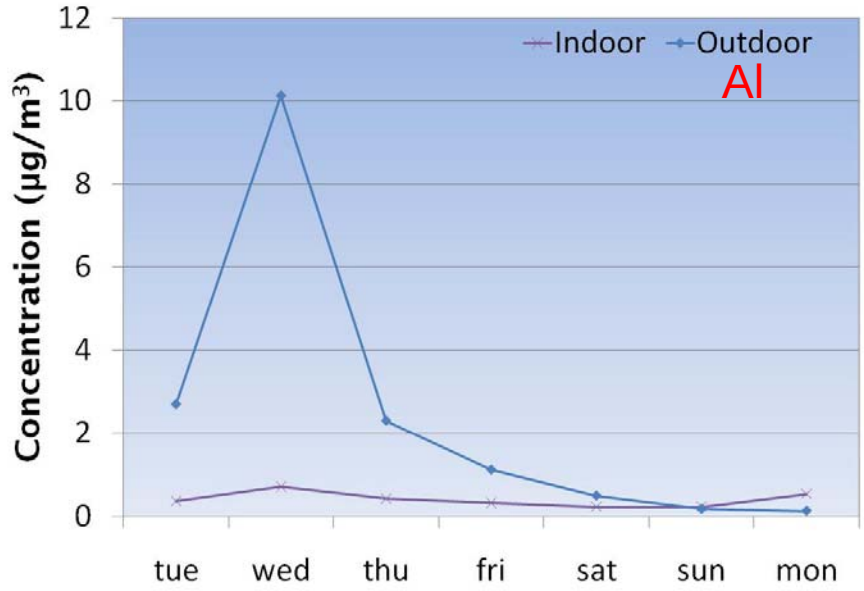


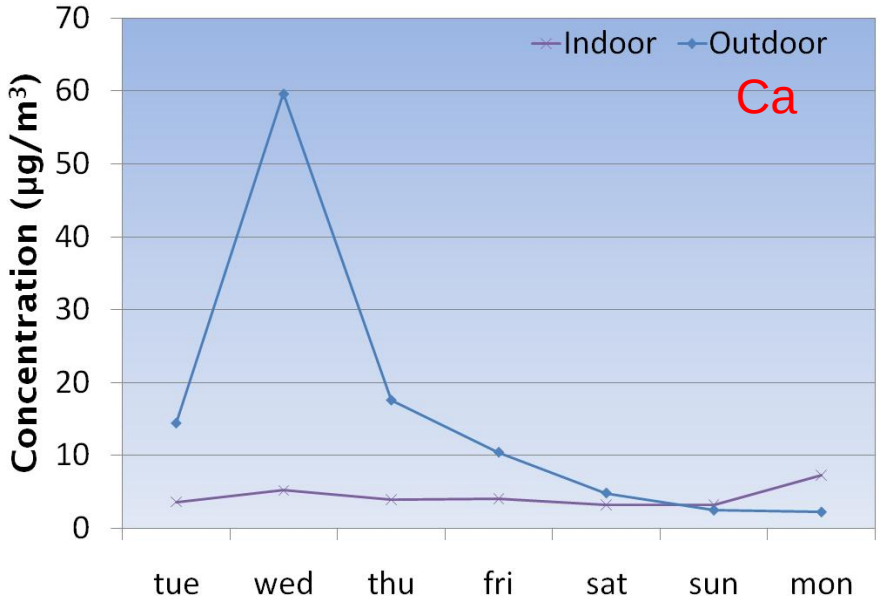

Al (22/11 – 28/11)
Indoor
Outdoor
Concentration (µg/m³)
12
10
8
6
4
2
0
tue
wed
thu
fri
sat


Al (07/02 – 13/02)
Indoor
Outdoor
Concentration (µg/m³)
12
10
8
6
4
2
0
tue
wed
thu
fri
sat
sun
mon


Indoor
Outdoor
Si
Concentration (µg/m³)
50
45
40
35
30
25
20
15
10
5
0
tue
wed
thu
fri
sat
sun
mon

07/02 – 13/02


Indoor
Outdoor
Al
Concentration (µg/m³)
12
10
8
6
4
2
0
tue
wed
thu
fri
sat
sun
mon


Indoor
Outdoor
Ca
Concentration (µg/m³)
70
60
50
40
30
20
10
0
tue
wed
thu
fri
sat
sun
mon

Conclusions

- Safe levels of SO_2 were found;
- HVAC system seemed to be effective (also in the worst conditions);
- No vertical gradients nor noticeable differences in concentrations were found in proximity of the statue.

Thank you!