SETAC EUROPE 28th ANNUAL MEETING
13–17 MAY 2018 I ROME, ITALY
Responsible and Innovative Research for Environmental Quality

Innovative And Low-Cost Monitoring Techniques for Evaluating the Spatial Variability of PM Components: Validation and Field Application

L. Massimi[1*], C. Perrino[2], M.E. Conti[3] and S. Canepari[1]

[1] **Department of Chemistry, Sapienza University of Rome (Rome), 00185, Italy.**

[2] C.N.R., Institute of Atmospheric Pollution Research, Monterotondo St. (Rome), 00015, Italy.

[3] Department of Management, Sapienza University of Rome (Rome), 00161, Italy.

[*]**Corresponding author e-mail: l.massimi@uniroma1.it**

The study of the **spatial distribution of atmospheric PM** and of its components is essential for a reliable identification of emission sources, the evaluation of particle dispersion over the territory and the assessment of personal exposure.

However, the very high cost of a network based on traditional PM samplers generally prevents the achievement of these goals.

- A low-cost, self-powered and automatic device for PM sampling on membrane filters has been recently become available:

  HSRS - High Spatial Resolution Sampler

  (FAI Instruments, Fonte Nuova, Rome, Italy)

- The sampler, constitutes promising possibility to build **low-cost networks** for the **spatial mapping of PM** and its main chemical components without using the traditional biomonitors (such as lichen transplants).

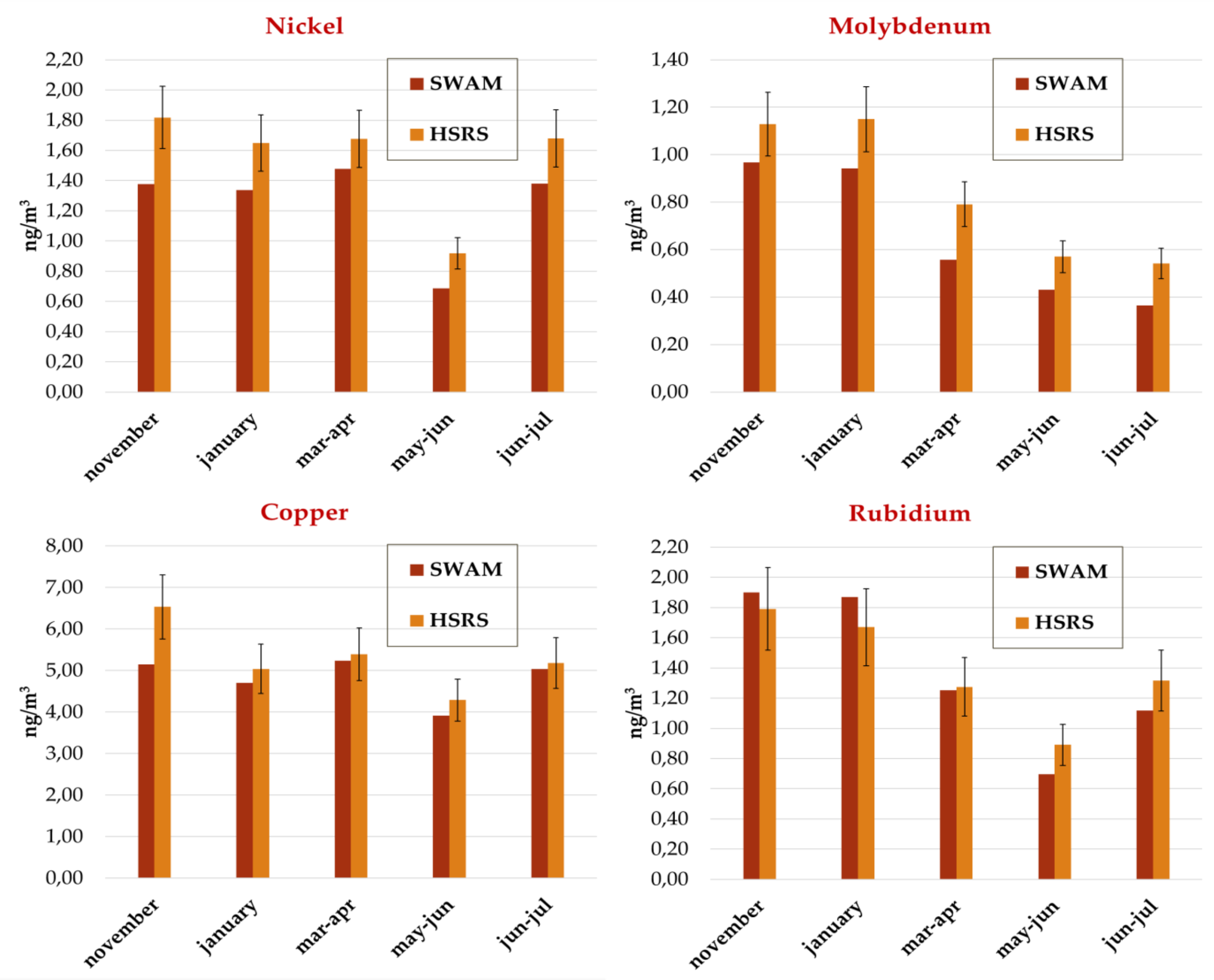
HSRS operates at the **flow rate of 0.5 l min^{-1}**.
It is equipped with a small solar panel and a rechargeable battery.

The device has been **validated during a 1-year study** focused on the concentration of PM_{10} mass, ions, levoglucosan, polycyclic aromatic hydrocarbons (PAH) and elements.

It showed very **good performance in terms of repeatability of the samplings (about 10 % for the elements)**, which is the essential characteristic to build a reliable network.

The results were **compared with** the average values obtained from daily samplings carried out by a **reference sampler** operating at the flow rate of 2.3 m^3 h^{-1}.

- The comparison with the reference sampler was very **good for stable, fine components** (e.g.: sulphate, potassium, levoglucosan, **elements**) and satisfactory for stable coarse components (e.g.: sodium, magnesium, calcium).



The sampler has been **employed along with lichen transplants**, to evaluate the spatial variability of PM_{10} mass concentration and its main chemical components, **in the area of Terni, a urban/industrial hot-spot** sited in an intramountain depression of Central Italy (Massimi et al. 2017).

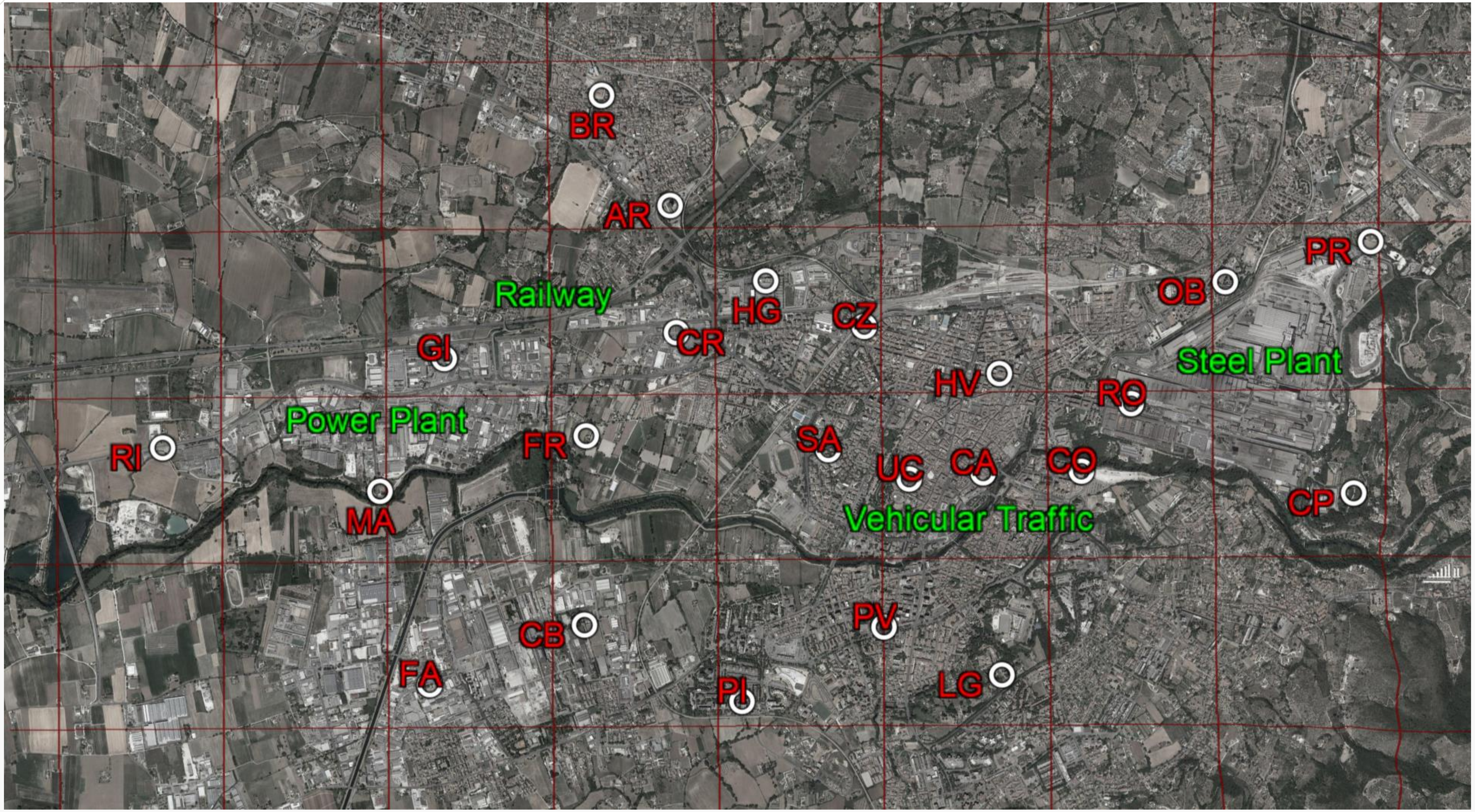
Terni is characterized by the presence of typical urban **PM emission sources** such as **vehicular traffic**, **domestic heating** and industrial emission sources such as a **power plant** for waste treatment and a **steel plant**.

- Peculiar geomorphological and meteorological conditions of Terni basin limit the dispersion and enhance the **accumulation of atmospheric pollutants**.

- Terni appeared an **ideal area** to test and validate innovative and low-cost monitoring techniques **for evaluating the spatial variability of PM_{10}** and its main chemical components.

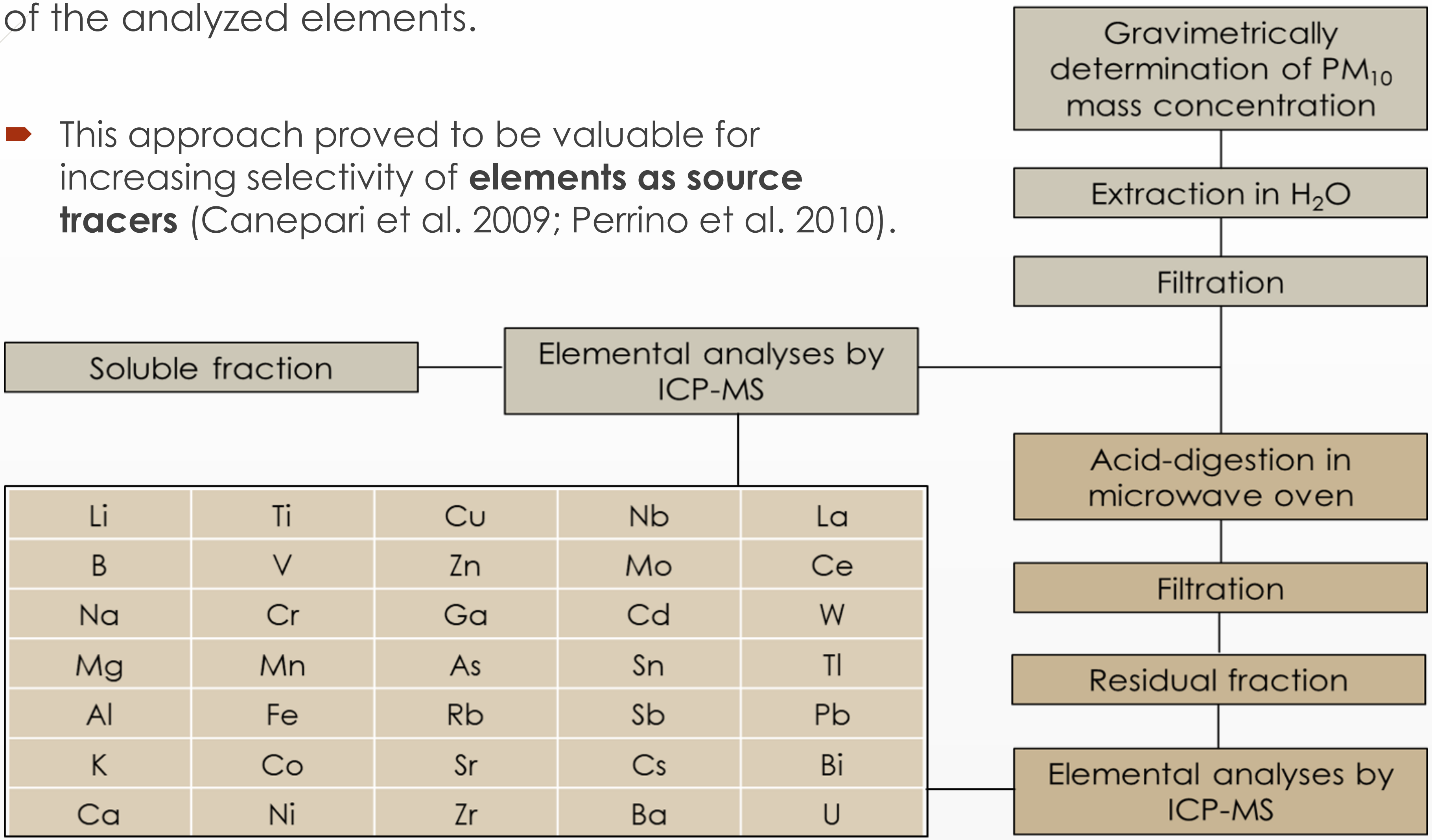
23 HSRS were located at different collection sites to design an **extended, dense and low-cost monitoring network** across Terni. A **lichen transplant** (*E. prunastri)*, fixed on a plastic net was exposed **at each monitoring site** for measuring the elements' bioaccumulation at 5-months and at 1-year of sampling.

Localizations of the samplers and of the lichen biomonitors **were chosen,** with the support of the Terni district of ARPA Umbria, in order **to evaluate the impact of different local PM_{10} emission sources**.



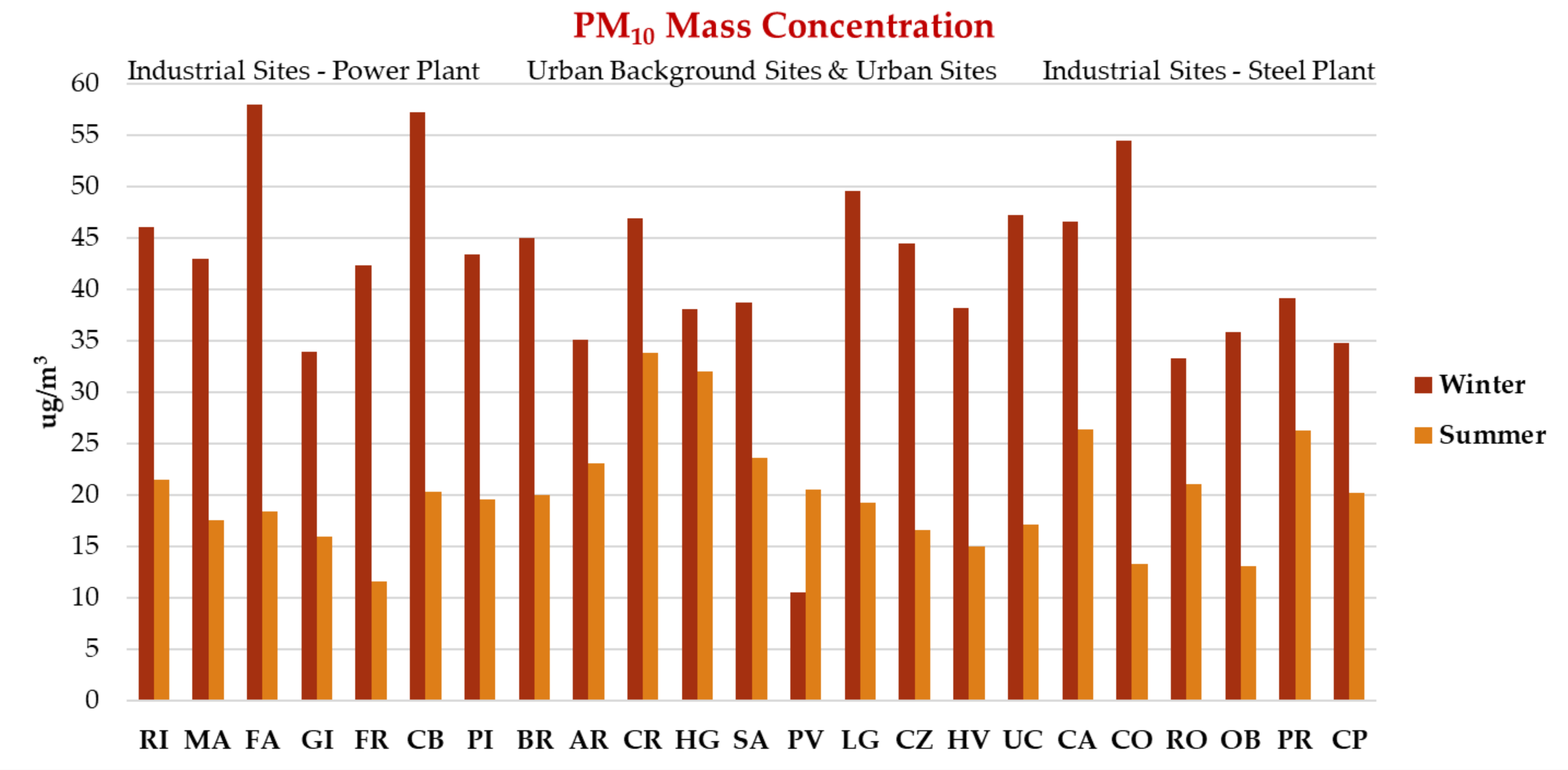
Chemical analysis of the PM samples was focused on the elemental content, using a **chemical fractioning procedure** that allowed us to discriminate water-soluble and insoluble fractions
of the analyzed elements.

- This approach proved to be valuable for increasing selectivity of **elements as source tracers** (Canepari et al. 2009; Perrino et al. 2010).

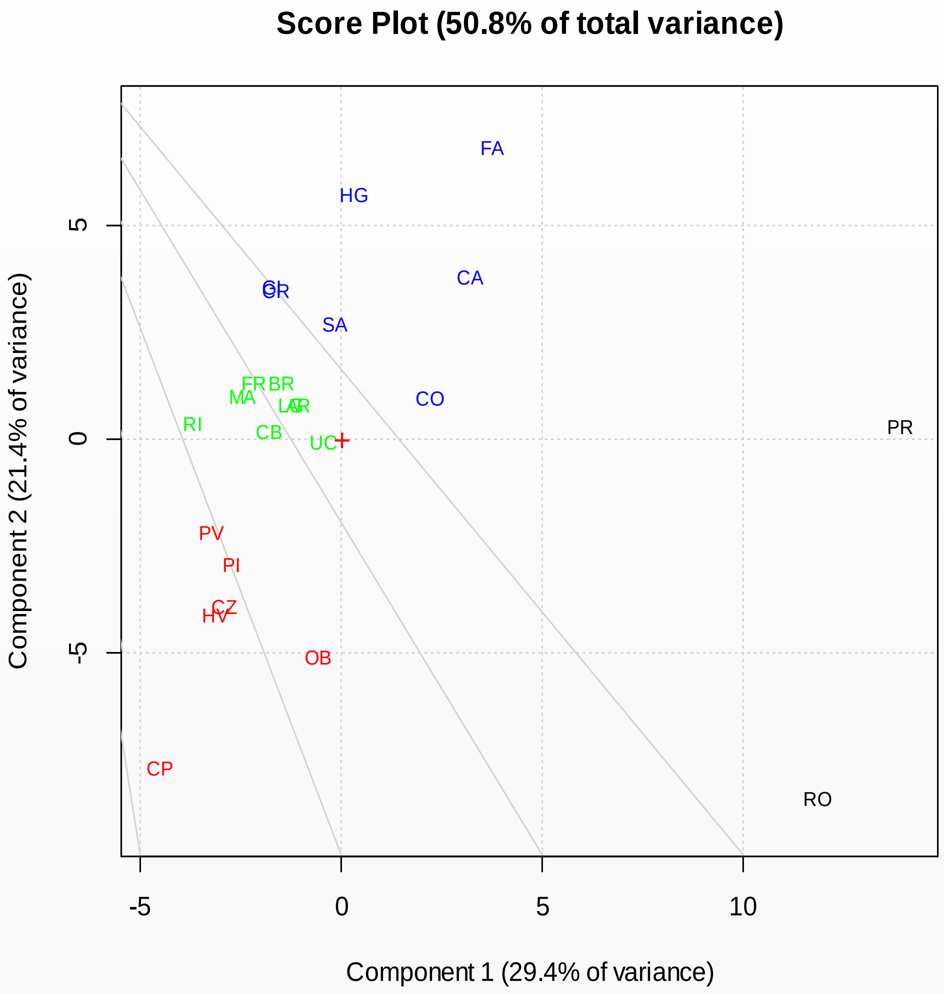


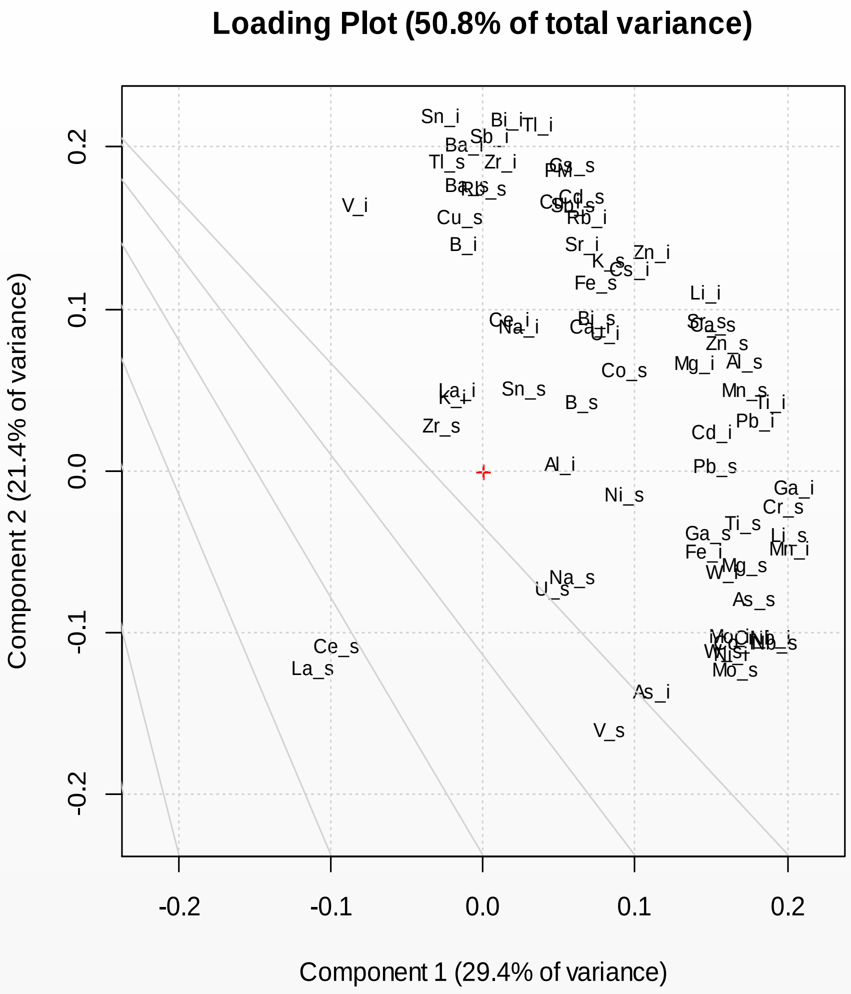
Li	Ti	Cu	Nb	La
B	V	Zn	Mo	Ce
Na	Cr	Ga	Cd	W
Mg	Mn	As	Sn	Tl
Al	Fe	Rb	Sb	Pb
K	Co	Sr	Cs	Bi
Ca	Ni	Zr	Ba	U

Spatially resolved data, obtained by **monthly sampling in parallel** at 23 monitoring sites in Terni, **allowed to assess the spatial variability of PM_{10} and** elemental mass concentrations.
PM samplings at each site enabled **to evaluate the potential of lichens as biomonitors for spatially resolved analyses.**

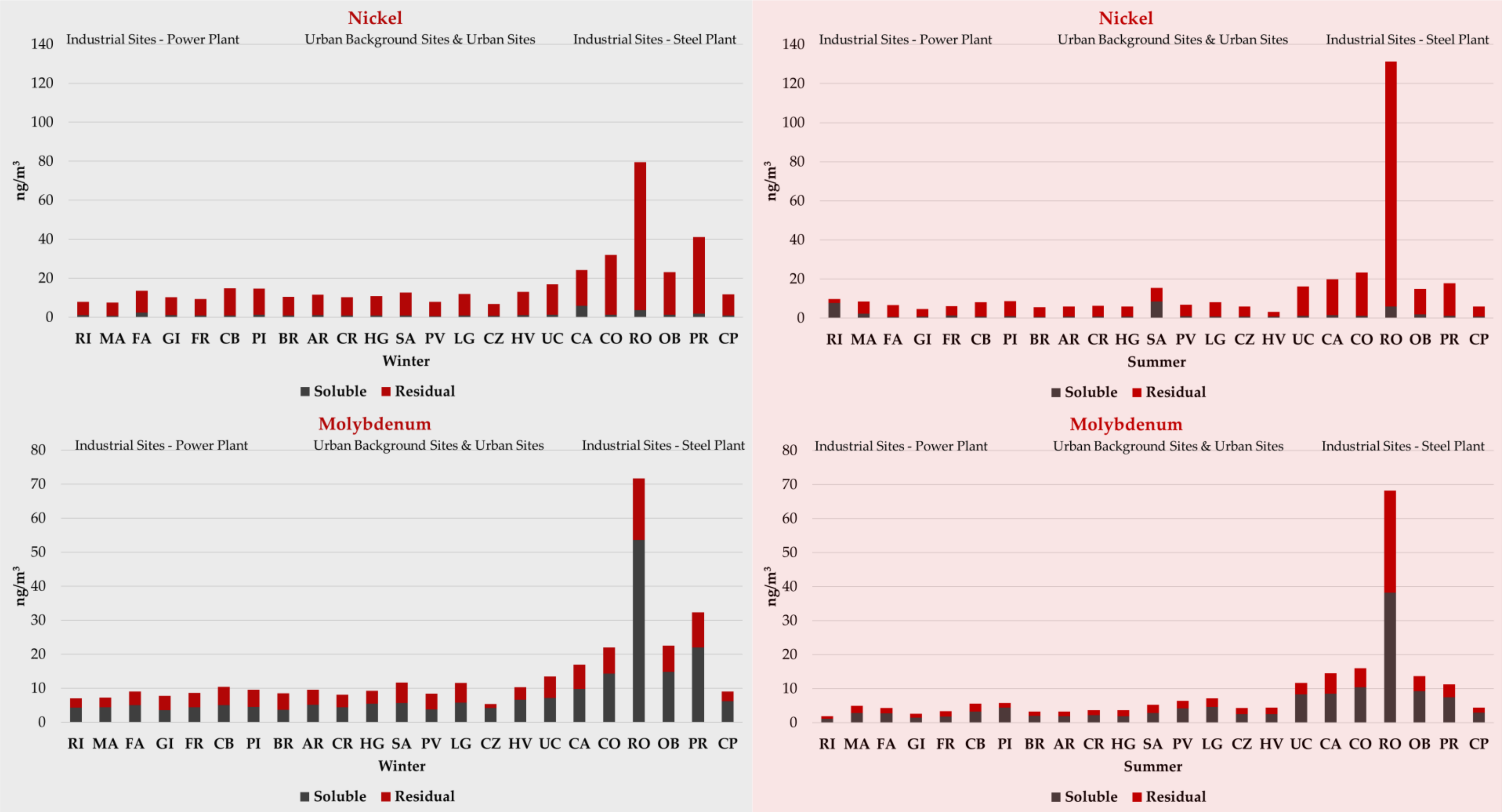


A principal component analysis (**PCA**) was performed on the data yielded at each collection site in order **to individuate the elements tracers of the main emission sources** and their action at each monitoring site.

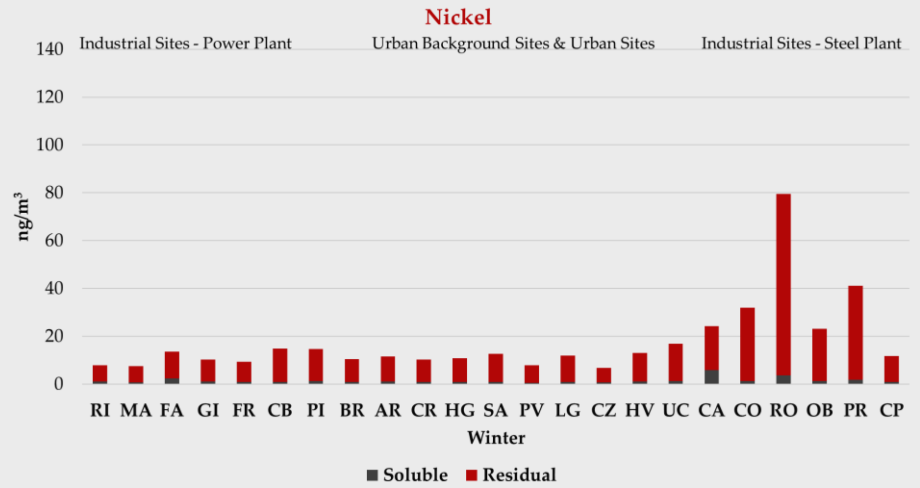


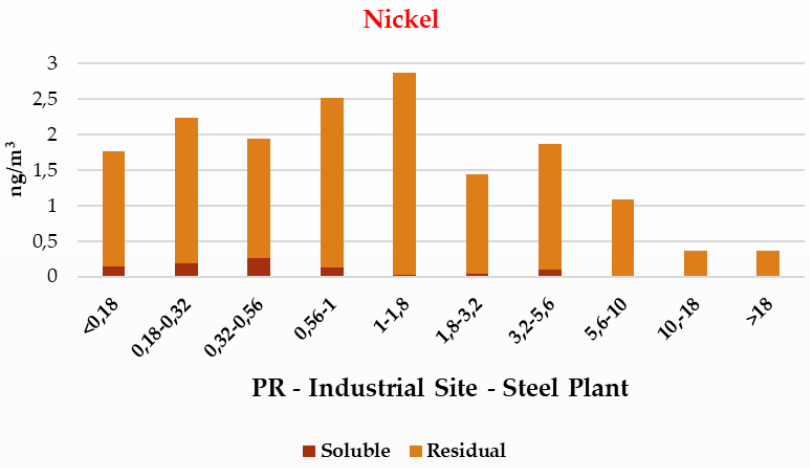


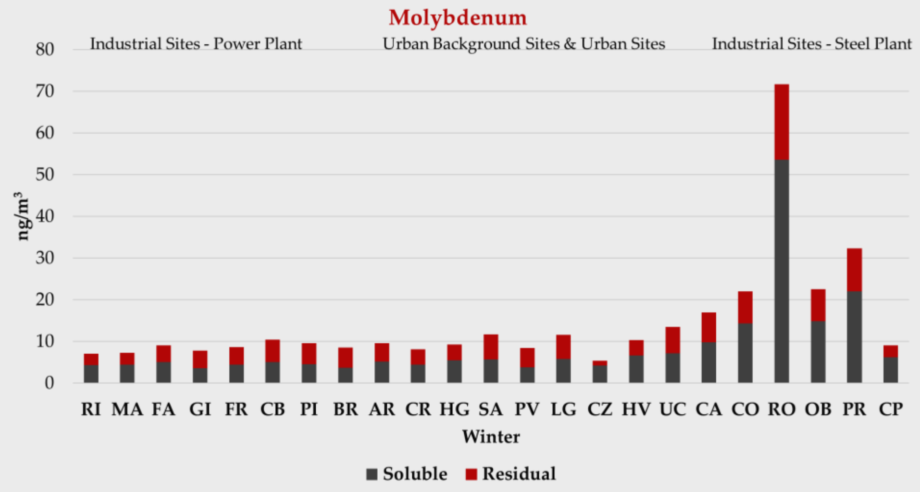
Spatial variability of **Ni, Fe, Cr, Li, Ti, Co, Ga (insoluble fraction), Mo, Mn, Pb, Mg, Zn, As, Nb, W (insoluble and water-soluble fraction)** concentrations showed the **steel plant** role in the emission of PM_{10}.

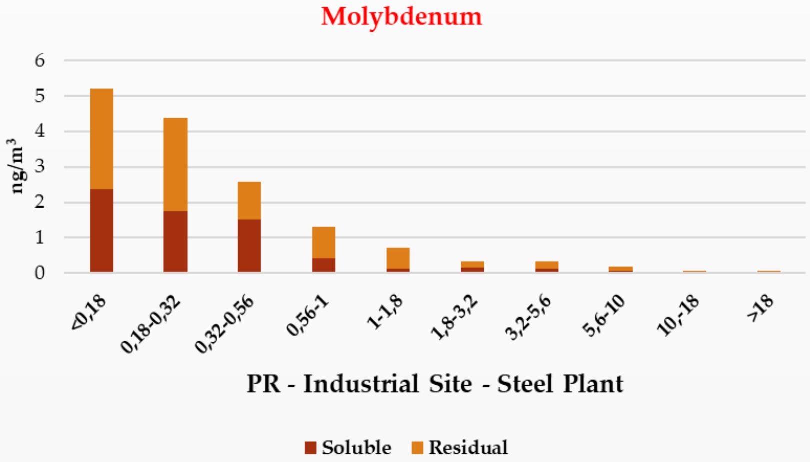


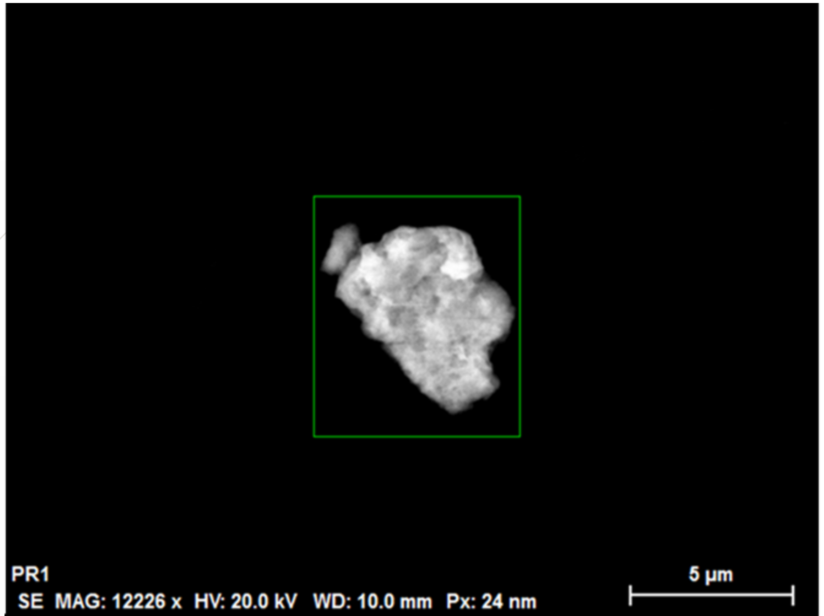
Spatial variability of **Ni, Fe, Cr, Li, Ti, Co, Ga (insoluble fraction), Mo, Mn, Pb, Mg, Zn, As, Nb, W (insoluble and water-soluble fraction)** concentrations showed the **steel plant** role in the emission of PM_{10}.

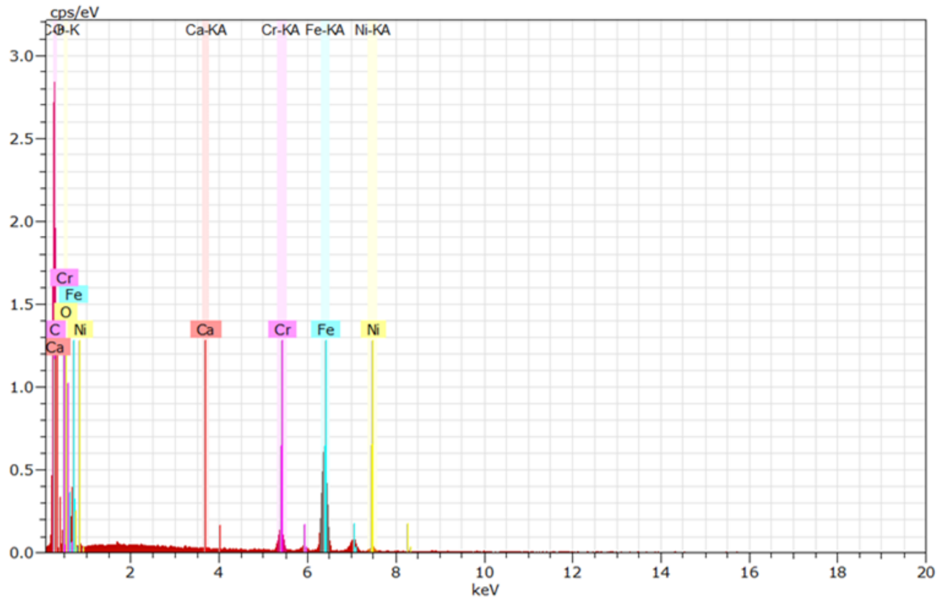




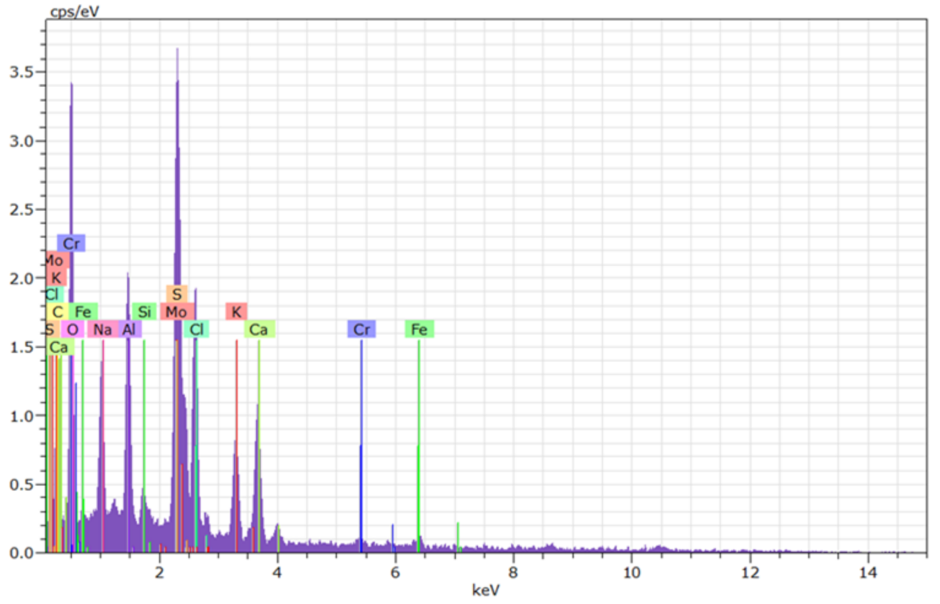




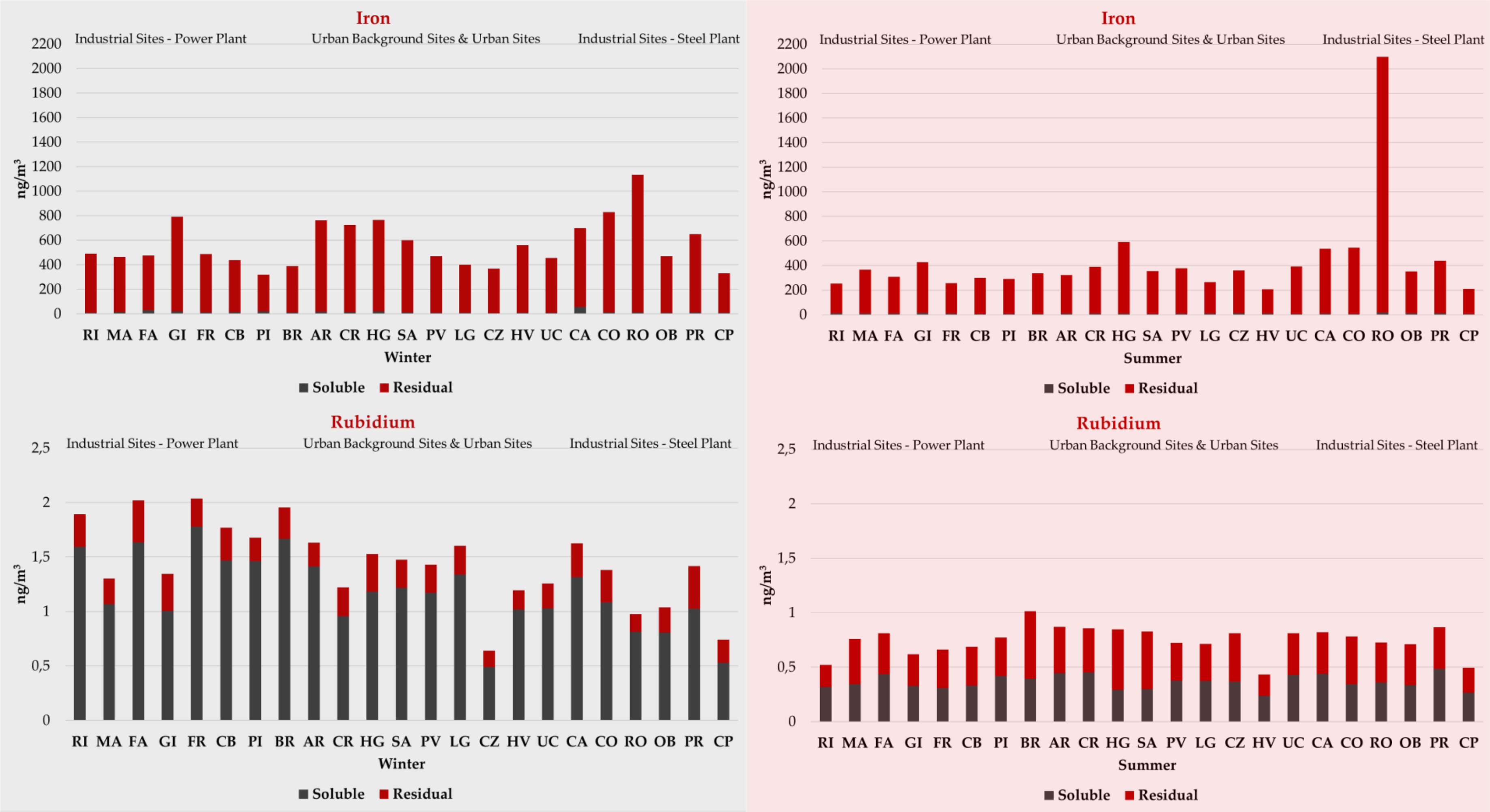

PR1
SE MAG: 12226 x HV: 20.0 kV WD: 10.0 mm Px: 24 nm
5 µm


cps/eV
Ca-KA
Cr-KA Fe-KA Ni-KA
Cr
Fe
O
C
Ni
Ca
keV

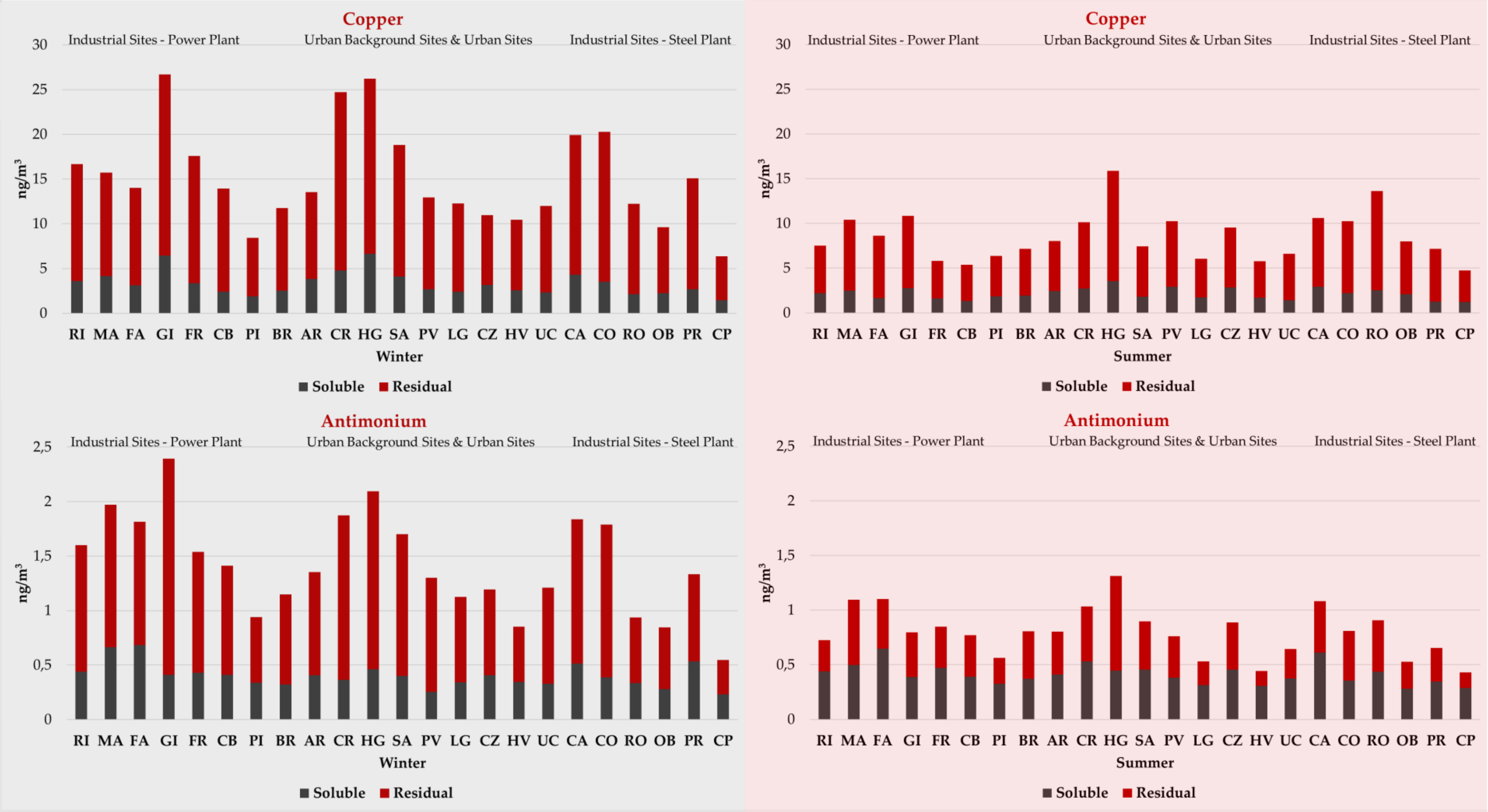

prs7_11
PRS7
SE MAG: 66615 x HV: 15.0 kV WD: 10.5 mm Px: 5 nm
1 µm


cps/eV
Cr
K
Cl
C
Fe
O
Na
Al
Si
S
Mo
K
Ca
Cr
Fe
keV

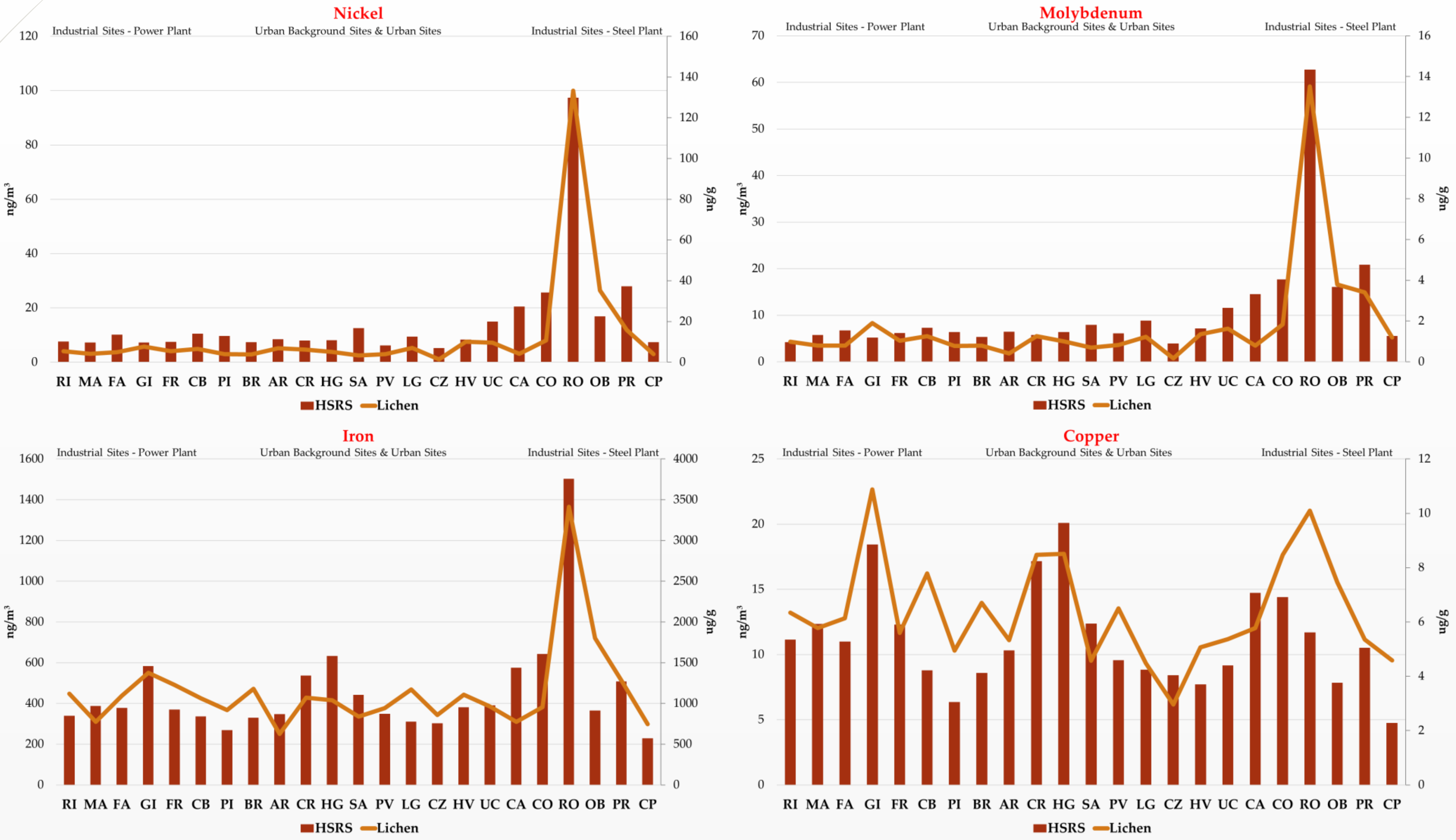
Spatial variability of **Fe (insoluble fraction)** resulted to be correlated also with **vehicular traffic** and **railway** emission sources. **Rb, Tl** and **K (soluble fraction)** were confirmed to be good tracers of **biomass combustion** processes.



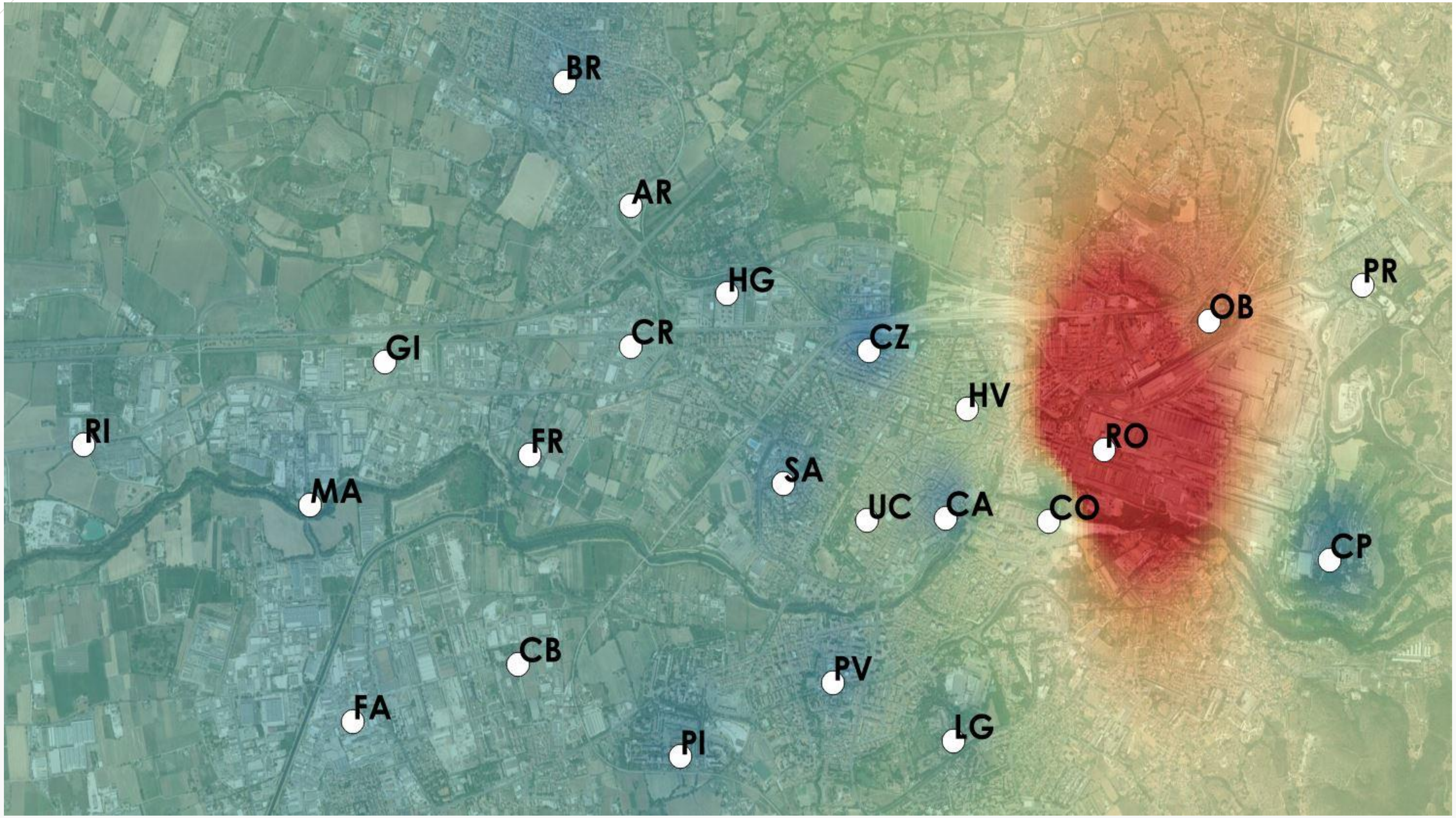
The role of **vehicular traffic** and **railway** emission sources was also confirmed by the spatial variability of **Zr, Sn (insoluble fraction), Sb, Cu** and **Ba (insoluble and water-soluble fraction).**



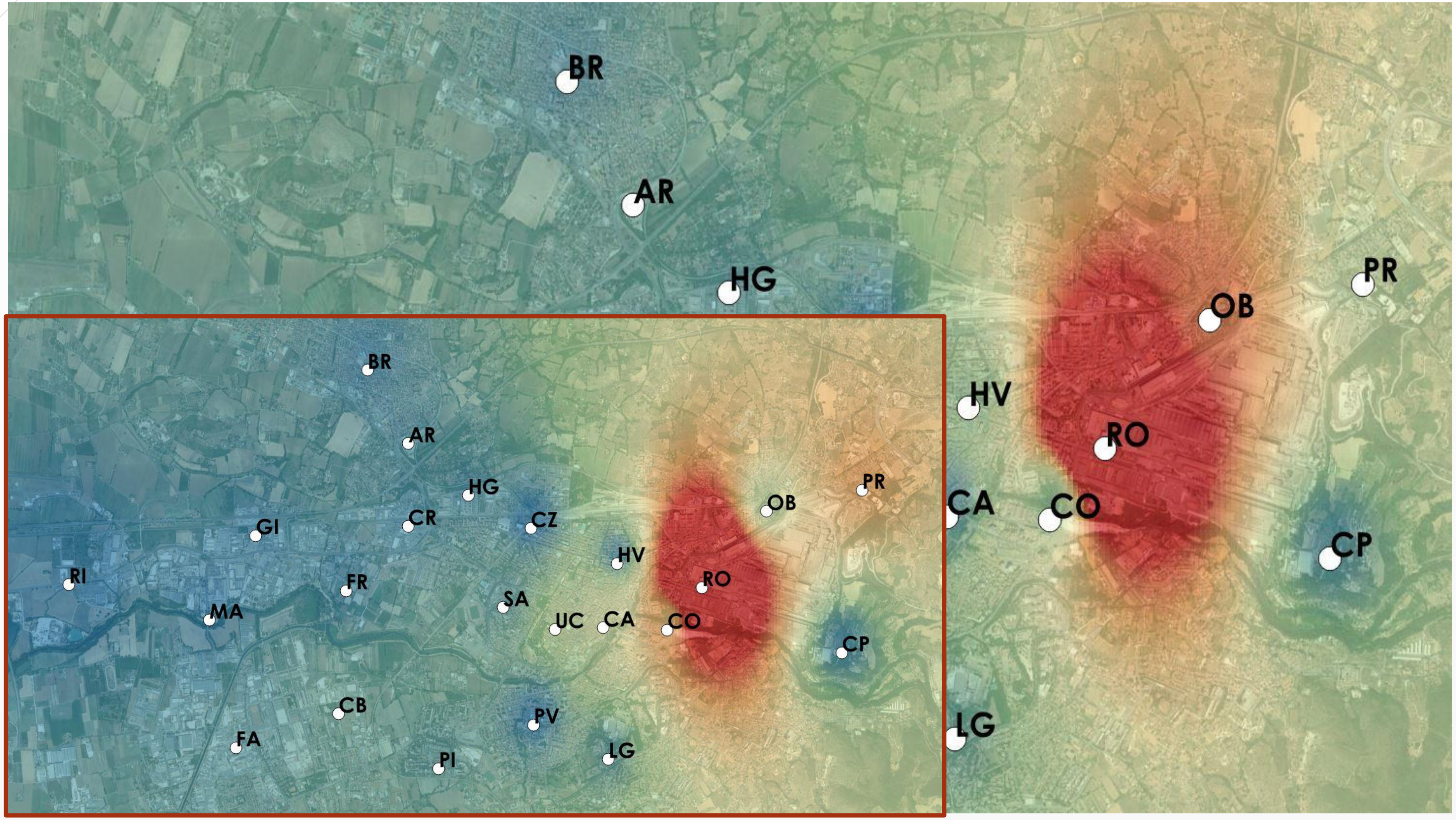
Lichen transplants appeared **good biomonitors for** evaluating the spatial variability of the **elements emitted at high concentration** by the **steel plant** and **vehicular traffic** emission sources (e.g.: nickel, copper).



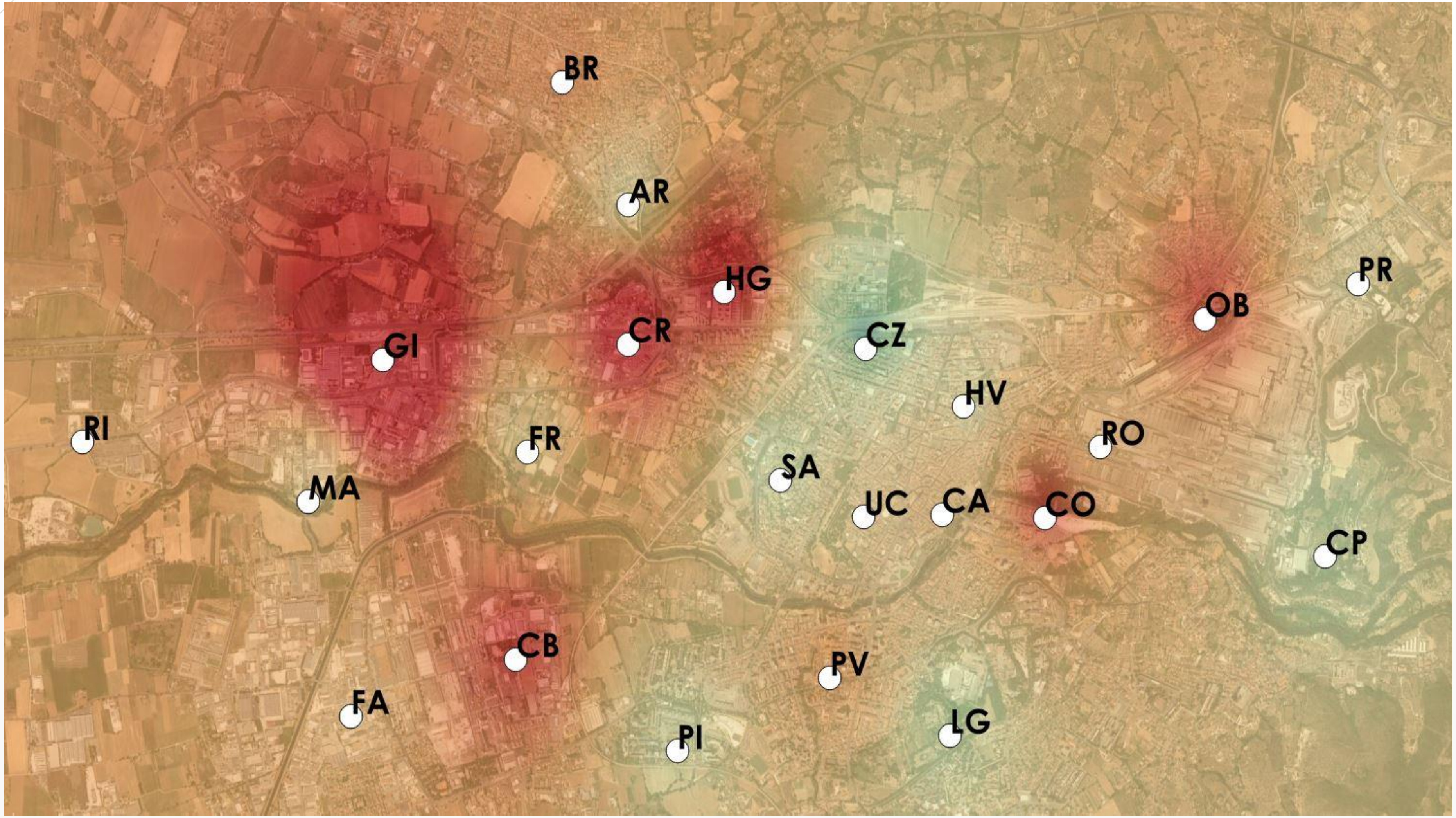
Lichen transplants appeared **good biomonitors for** evaluating the spatial variability of the **elements emitted at high concentration** by the **steel plant** and **vehicular traffic** emission sources (e.g.: nickel, copper).



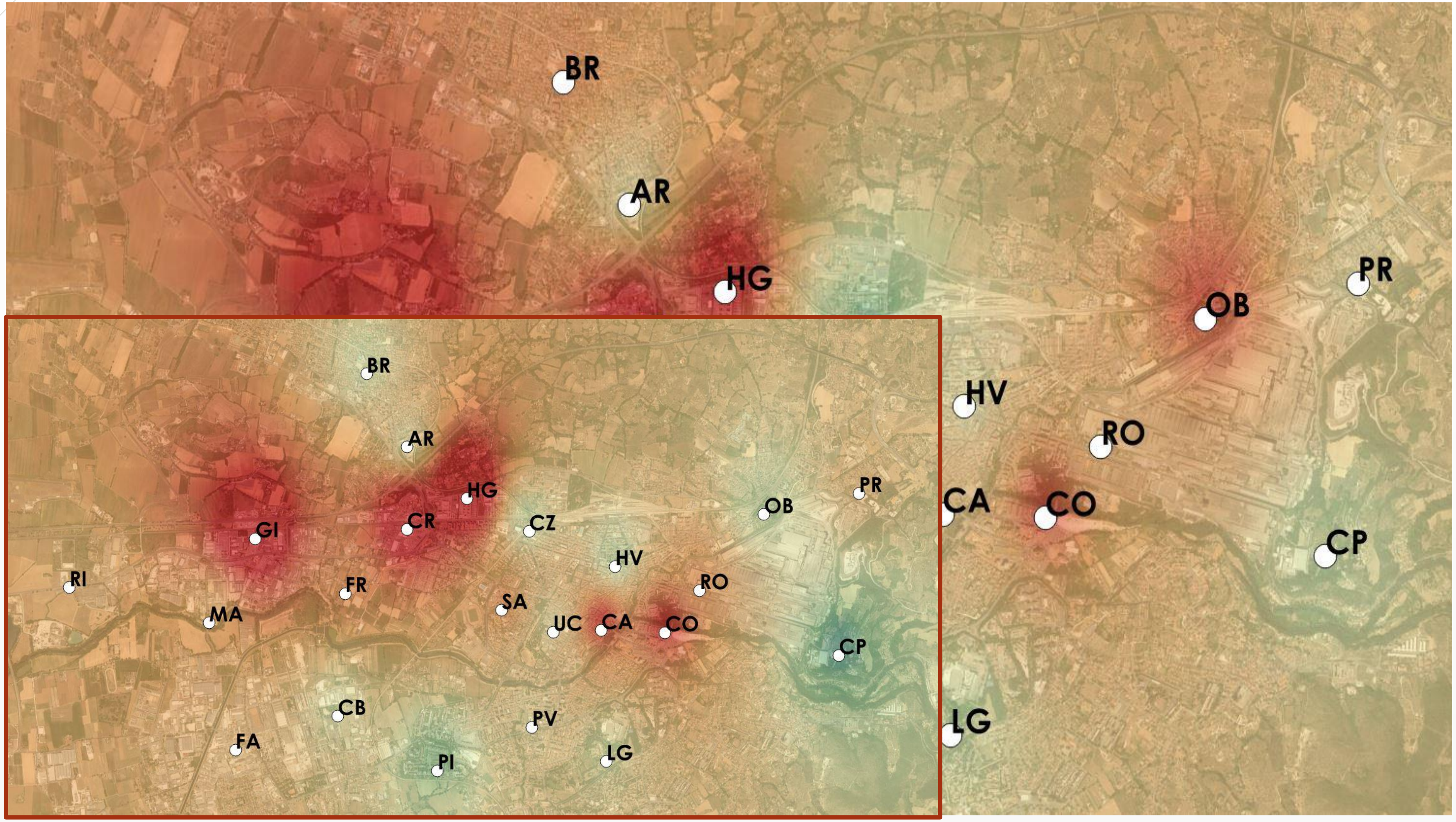
Lichen transplants appeared **good biomonitors for** evaluating the spatial variability of the **elements emitted at high concentration** by the **steel plant** and **vehicular traffic** emission sources (e.g.: nickel, copper).



Lichen transplants appeared **good biomonitors for** evaluating the spatial variability of the **elements emitted at high concentration** by the **steel plant** and **vehicular traffic** emission sources (e.g.: nickel, **copper**).



Lichen transplants appeared **good biomonitors for** evaluating the spatial variability of the **elements emitted at high concentration** by the **steel plant** and **vehicular traffic** emission sources (e.g.: nickel, **copper**).



CONCLUSIONS

- The HSRS, used for the first time in this monitoring campaign, allowed to build a **low-cost extended and dense monitoring network**, which was **able to represent the different emission source contributes** to the total PM_{10}.

- The innovative sampling procedures enabled the evaluation of the **potential of lichen transplants as biomonitors** for evaluating the spatial variability of the PM elemental components.

- The obtained results proved the **efficiency of the innovative and low-cost monitoring techniques** for the evaluation of the spatial variability of PM_{10} and its elemental components.

Thank you for your kind attention

Lorenzo Massimi
Corresponding author e-mail: l.massimi@uniroma1.it

Canepari, S., Pietrodangelo, A., Perrino, C., Astolfi, M. L., & Marzo, M. L. (2009). Enhancement of source traceability of atmospheric PM by elemental chemical fractionation. *Atmospheric Environment*, *43*(31), 4754-4765.

Massimi, L., Ristorini, M., Eusebio, M., Florendo, D., Adeyemo, A., Brugnoli, D., & Canepari, S. (2017). Monitoring and evaluation of Terni (Central Italy) air quality through spatially resolved analyses. *Atmosphere*, *8*(10), 200.