

# Air quality in stations and trains in the Barcelona subway system

Vânia Martins<sup>1,2</sup>, Teresa Moreno<sup>1</sup>, María Cruz Minguillón<sup>1</sup> and Xavier Querol<sup>1</sup>

<sup>1</sup> Institute of Environmental Assessment and Water Research (IDAEA-CSIC), Barcelona, Spain

<sup>2</sup> Department of Analytical Chemistry, Faculty of Chemistry, University of Barcelona, Barcelona, Spain

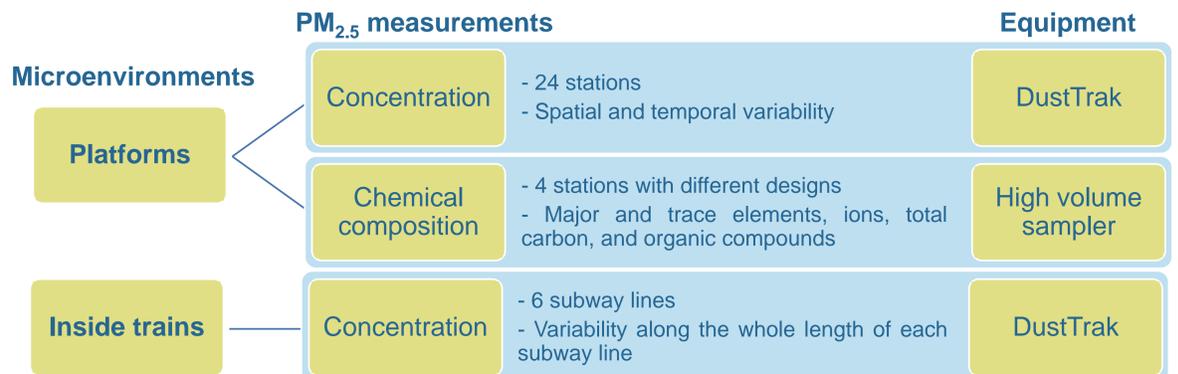
vania.ferreira@idaea.csic.es

## Introduction

- People living in metropolitan areas usually spend a considerable amount of their **daily time commuting**. In today's society, the **subway** is a well-developed and highly promoted **transportation mode** because of its comfort, high speed, environmental friendliness, and large transport capacity.
- Prior studies in subway systems of several cities worldwide indicated that **particulate matter (PM) concentrations** are generally **higher** in these environments than those measured in ambient air [1].
- The passengers are exposed to **indoor air potentially polluted** by various sources, related mostly to the motion of the trains and the movement of passengers [2].

## Methodology

- **Air quality measurements** during two seasonal periods: **Warmer** and **Colder**.



## Results & Discussion

### PM concentrations on platforms

#### Comparison with outdoor environment

- Higher on the platforms than in the outdoor environment
- Most of the PM load is generated within the subway system

#### Seasonal periods

- Higher during the colder period, due to platform ventilation differences between seasons (stronger ventilation during warmer period)

#### Different stations

- Lower on the new stations, due to the stations design with platform screen doors (PSDs), lower train frequency and more advanced ventilation setup

#### Daily patterns

- Typical diurnal cycle driven by the ventilation settings and secondarily by the train frequency
- Lower during weekends, due to the lower frequency of trains

#### Temporal and spatial variations (Representative cases)

- More variable in colder period during shorter time scales
- Increase when train enters the platform and decrease when it departs
- Higher at the train entry edge and a decreasing trend along the platform
- Higher in areas closer to passengers' access

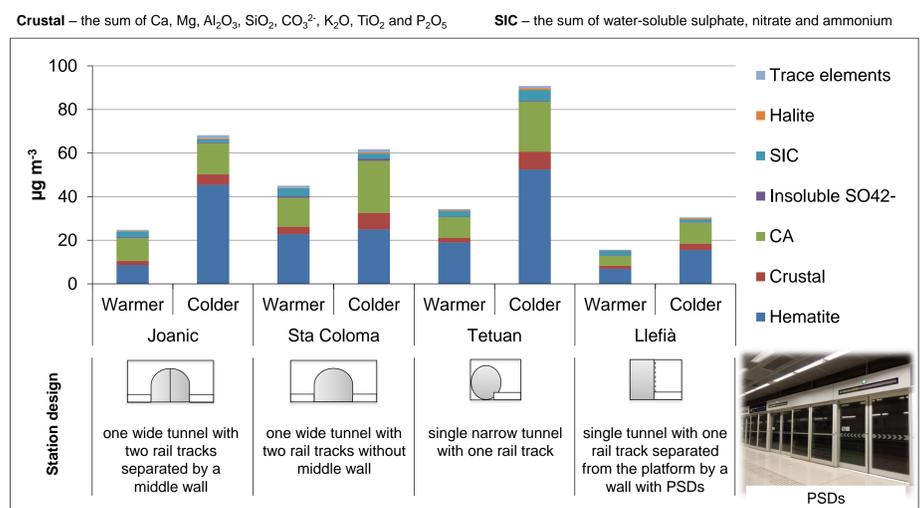
### PM concentrations inside trains

- Lower in the new technologically advanced line, with more efficient mechanical ventilation system
- No seasonal pattern was found
- Maximum peak in the central part of the lines, coinciding with the maximum influx of passengers

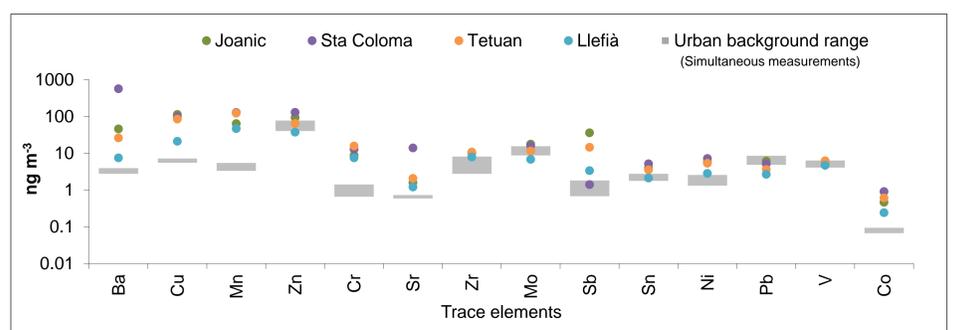


### Chemical composition on platforms

- Distributions of the PM<sub>2.5</sub> components were similar at the 4 subway stations.
- PM<sub>2.5</sub> was composed of around 45% hematite, 27% carbonaceous aerosol (CA), 7.6% crustal matter, 5.9% secondary inorganic compounds (SIC), 1.4% trace elements, 1.0% insoluble sulphate and 1.0% halite.



- The highest concentration of trace elements was observed in Santa Coloma station in both periods while the opposite was obtained in Llefià (new) station.
- Trace elements with higher enrichment compared to the urban background, that is, those associated with the presence of particulate sources within the subway system were Ba, Cu, Mn, Cr, Sr and Sb.



## Conclusions

- Concentrations of PM inside trains were lower than those on the platforms.
- Most PM is generated within the subway system, due to the abrasion and wear of rail tracks, catenaries, pantographs, wheels and brakes, with distinct trace elements composition.
- Variations in PM levels between seasons were influenced by the ventilation system.
- PM measurements showed also temporal and spatial variations along the platforms, related to the differences in the time, place, design of the stations and tunnels, train frequency and passenger densities.

#### References:

[1] Nieuwenhuijsen MJ, Gómez-Perales JE, Colville RN. Levels of particulate air pollution, its elemental composition, determinants and health effects in metro systems. *Atmos Environ*. 2007; 41, 7995–8006.

[2] Martins V, Moreno T, Minguillón MC, Amato F, de Miguel E, Capdevila M, Querol X. Exposure to airborne particulate matter in the subway system. *Sci. Total Environ*. 2015; 511, 711–722.

**Acknowledgements:** This study was supported by the Spanish Ministry of Economy and Competitiveness and FEDER funds (METRO CGL2012-33066), the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 315760 HEXACOMM and the IMPROVE LIFE project (LIFE13 ENV/ES/000263).