Physical-chemical characterisation of atmospheric aerosol in León (NW Spain): an integrated study during the period of highest consumption of coal for heating purposes

C. Gonçalves[1], E.D. Vicente[1], C. Blanco-Alegre[1], A.I. Calvo[1], A. Rodríguez-Fernández[2], A. Sánchez de la Campa[3], F. Giardi[4], S. Nava[4], G. Calzolai[4] and R. Fraile[1]

[1]Department of Physics, Universidad de León, Campus de Vegazana, 24071, León, Spain
[2]Department of Biodiversity and Environmental Management, Universidad de León, León, Spain
[3]Associate Unit CSIC-University of Huelva "Atmospheric Pollution", Centre for Research in Sustainable Chemistry (CIQSO), University of Huelva, Huelva, E21071, Spain
[4]INFN - Firenze, National Institute for Nuclear Physics - Florence division, 50019, Sesto Fiorentino, Italy

Introduction

In the last few years, the **World Health Organisation** has identified **air pollution** as the greatest **environmental health risk** and one of the main drivers of **climate change** (WHO, 2019). The climate effect provoked by the concentration of **atmospheric aerosols** is complex and depends on aerosols chemical, physical and optical properties. The origin of these aerosols can be very diverse and is often related to **seasonal events**, namely the use of **heating devices** during the **coldest periods** of the year. A sampling campaign was set in an area characterised by residential, commercial and service sectors in the city centre of **León** (NW Spain), with the aim of studying the **environmental impact** of the use of **coal for heating purposes**.

Methodology

Sampling campaign

The sampling site was located on a public building in downtown León (42°35´59.5" N 5°34´34.3" W), at a height of around 20 m above street level (Figure 1). Measurements were conducted between **December 2021 and Abril 2022**, which coincides with the coldest months of the year.

Note: During the month of March, an extreme Saharan dust outbreak affected the study area. The days affected by this event were excluded from this study so as not to distort the results presented.

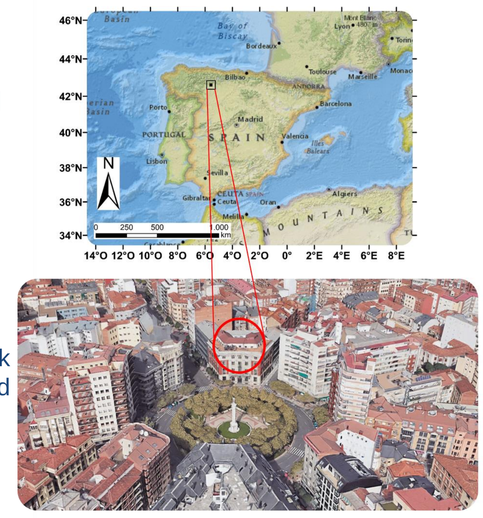


Figure 1. Sampling site location.

Analytical determinations

- Chemical characterisation

PM_{10} concentration (by gravimetry)

Organic and Elemental carbon (by thermal-optical method)

Water-soluble inorganic ions (by ion chromatography)

Elements (by PIXE)

- Optical characterisation

Aerosol absorption coefficient (σ_{ap}) (by aethalometer) → **Absorption Angström exponent (AAE)** (λ_1 = 370 nm and λ_2 = 950 nm)

Aerosol scattering coefficient (σ_{sp}) (by nephelometer) → **Scattering Angström exponent (SAE)** (λ_1 = 450 nm and λ_2 = 635 nm)

Results

- Chemical characterisation

- The average daily **temperature** was 8 °C, ranging from minimum values of 2 °C (in January) to a maximum of 14 °C (in April) (Figure 2).
- The average daily **PM_{10}** concentration was 20 µg m^{-3} with a minimum of 6.5 µg m^{-3} (in April) and a maximum of 41 µg m^{-3} (in February) (Figure 2).

PM_{10} and Temperature

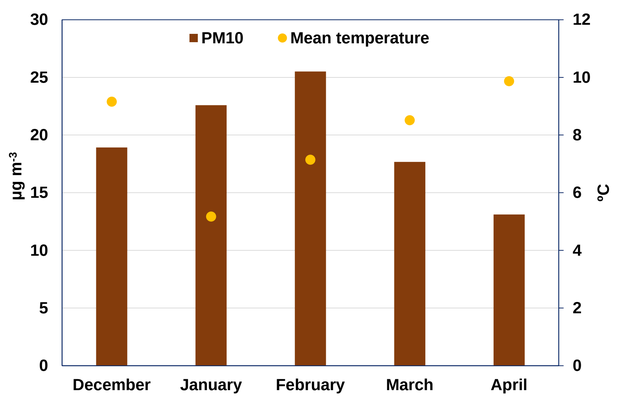
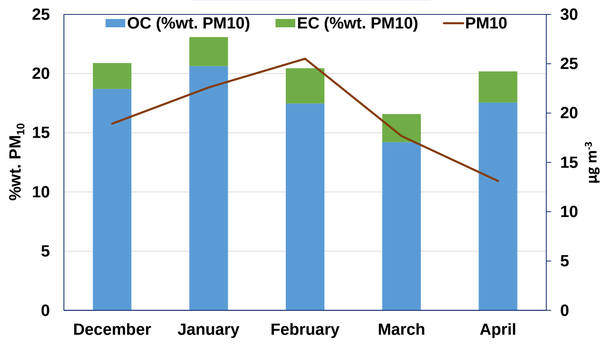


Figure 2. Average monthly of the PM_{10} concentrations and temperature during the studied period.

OC and EC



- On average, the **organic and elemental carbon** (OC, EC) represented 18 % ± 7.9 % wt. and 2.5 % ± 1.8 % wt. of the PM_{10} mass, respectively (Figure 3).

Figure 3. Monthly contribution of carbonaceous content to the particulate mass and PM_{10} concentration during the studied period.

- The **elements total concentration** represented on average 27 % wt. of the PM_{10} mass, with a minimum of 10 % and a maximum 45 %, in April and January, respectively. The dominant elements were Si, Cl, S and Na (Figure 4).

Elements

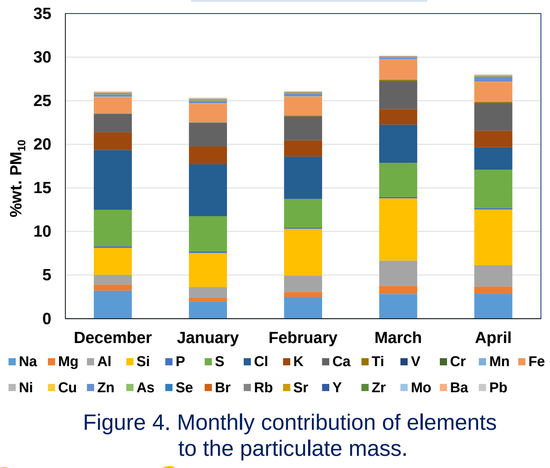


Figure 4. Monthly contribution of elements to the particulate mass.

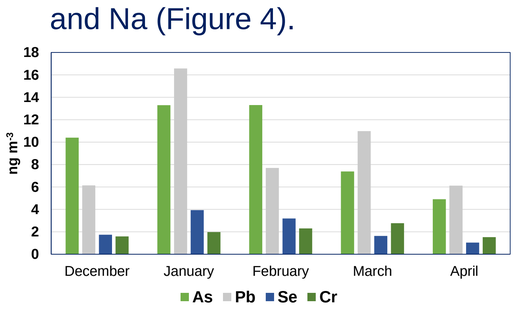


Figure 5. Average concentration of coal burning tracers during the studied period.

- An increase in **coal-burning tracers** (As, Pb, Se and Cr) is evident in the colder months (Figure 5).

Water-soluble inorganic ions

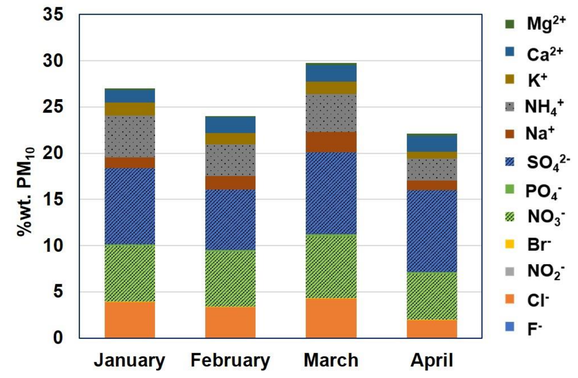


Figure 6. Monthly evolution of water-soluble inorganic ions to the particulate mass.

- The **ions total concentration** represented on average 25 % wt. of the PM_{10} mass, with a minimum of 6 % and a maximum 47 %, in February and March, respectively (Figure 6).

- Optical characterisation

	σ_{ap} (λ = 520 nm)				AAE (λ = 470 nm - 950 nm)			
	Mean	SD	Max.	Min.	Mean	SD	Max.	Min.
December	30.3	31.7	291	0.65	1.27	0.10	1.60	0.92
January	38.5	30.1	207	0.87	1.35	0.13	1.72	1.01
February	33.1	27.9	166	1.52	1.33	0.13	1.84	1.07

- The **AAE** value can provide an indication of the **aerosol composition**. When **BC** is the dominant absorbing aerosol component, the AAE value is **close to 1.**

	σ_{sp} (λ = 525 nm)				SAE (λ = 450 nm - 635 nm)			
	Mean	SD	Max.	Min.	Mean	SD	Max.	Min.
December	28.7	21.9	116	1.49	1.19	0.52	2.32	-1.95
January	41.8	22.8	186	5.57	1.57	0.29	2.39	-0.17
February	37.8	28.4	239	4.19	1.28	0.47	2.47	-0.44

- If the **scattering** is dominated by **fine particles**, **SAE** values are usually **equal to or greater than 1.5**, while values **close to 0** occur when the **scattering** is dominated by **coarse particles**.

Note: Scattering data from March to April not available.

Conclusions

The major use of heating devices during winter months in a city mainly with coal combustion has consequences for air quality, namely:

- The increase in PM_{10} concentration in the months with lower temperatures;
- January was the month with the highest OC contribution to the PM_{10}, related to the lower temperatures;
- The increase of coal burning tracers (As, Pb, Se) along the coldest months;
- The dominant water-soluble ions were sulphate, nitrate, ammonium and calcium to all studied months;
- AAE close to 1, since BC is the dominant absorbing aerosol component in the months with lower temperatures;
- The emission of fine particles from the coal burning for heating purposes brings the SAE, in the coldest months, close to 1.5.

References

World Health Organisation (2019) Ten threats to global health in 2019. Available online: https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019.

Acknowledgements

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