Indoor PM from residential coal combustion: levels and chemical composition

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Introduction

Coal is still the dominant fuel contributing to the $PM_{2.5}$ disease burden in several countries (McDuffie et al., 2021). Even though the greatest health losses caused by solid fuels combustion were recorded in Eastern and South-eastern Asia and Sub-Saharan Africa (IEA, IRENA, UNSD, World Bank 2022), coal combustion is still used as a source of heating in several European countries (Kerimray et al., 2017). Thus, considering that quantitative estimates of residential coal combustion for indoor air pollution levels in European countries are limited so far, this study intends to assess household PM levels in a household that relies on coal for wintertime heating. Additionally, the chemical characteristics of PM samples will be evaluated.

Methods

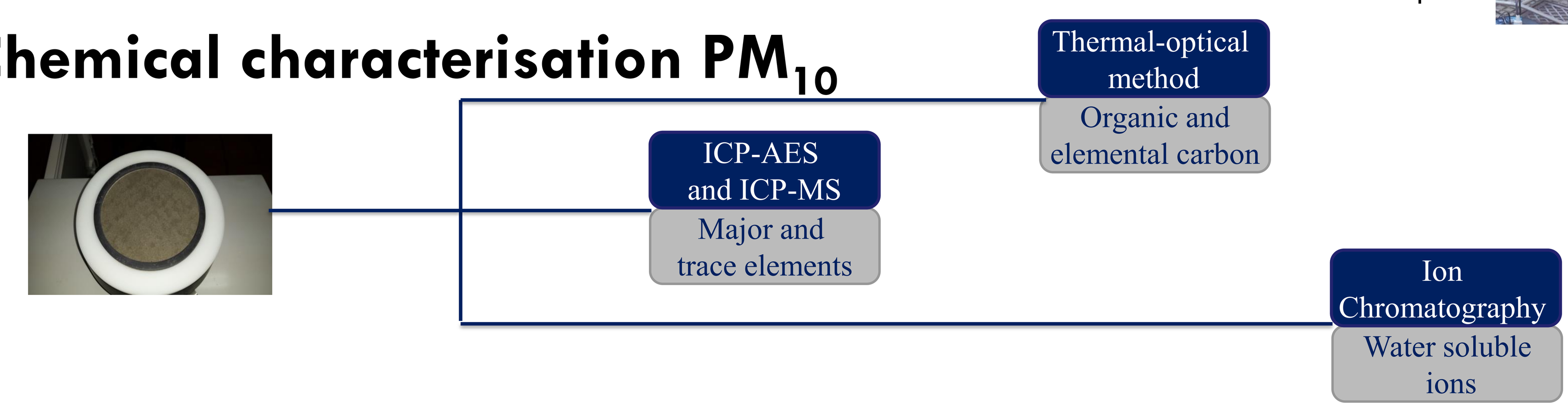
- **Sampling**

Source ON
Source OFF
Indoor and Outdoor

- PM_1, $PM_{2.5}$, PM_4 and PM_{10} (laser photometric instrument)
- Temperature, RH, CO_2, CO

- PM_{10} (gravimetric quantification)

- **Chemical characterisation PM_{10}**



Results

PM Measurements

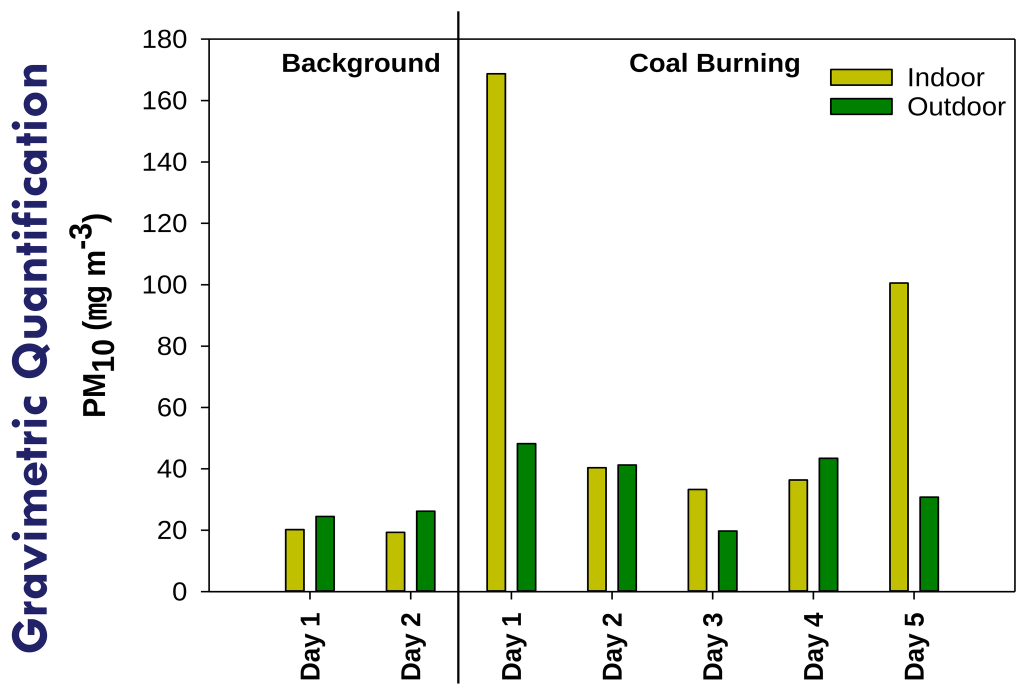


Figure 1. Average PM_{10} concentrations during coal combustion and without indoor activities (background).

Temperature, RH, CO_2, CO

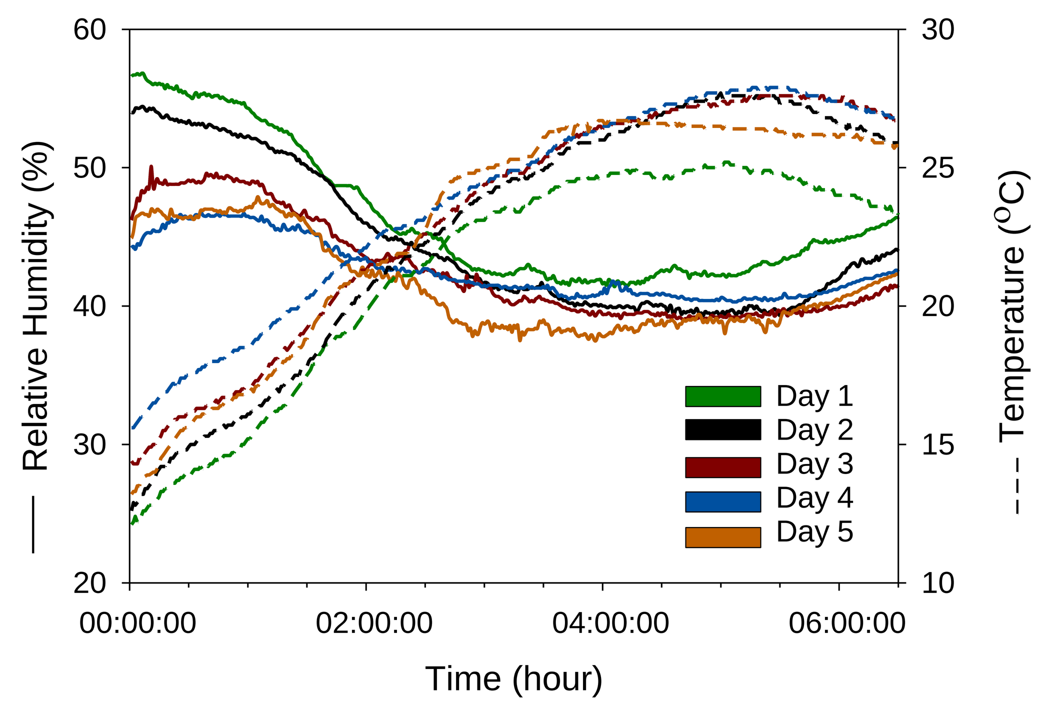


Figure 3. Indoor daily profiles of temperature and relative humidity during coal combustion.

PM Chemical Characterisation

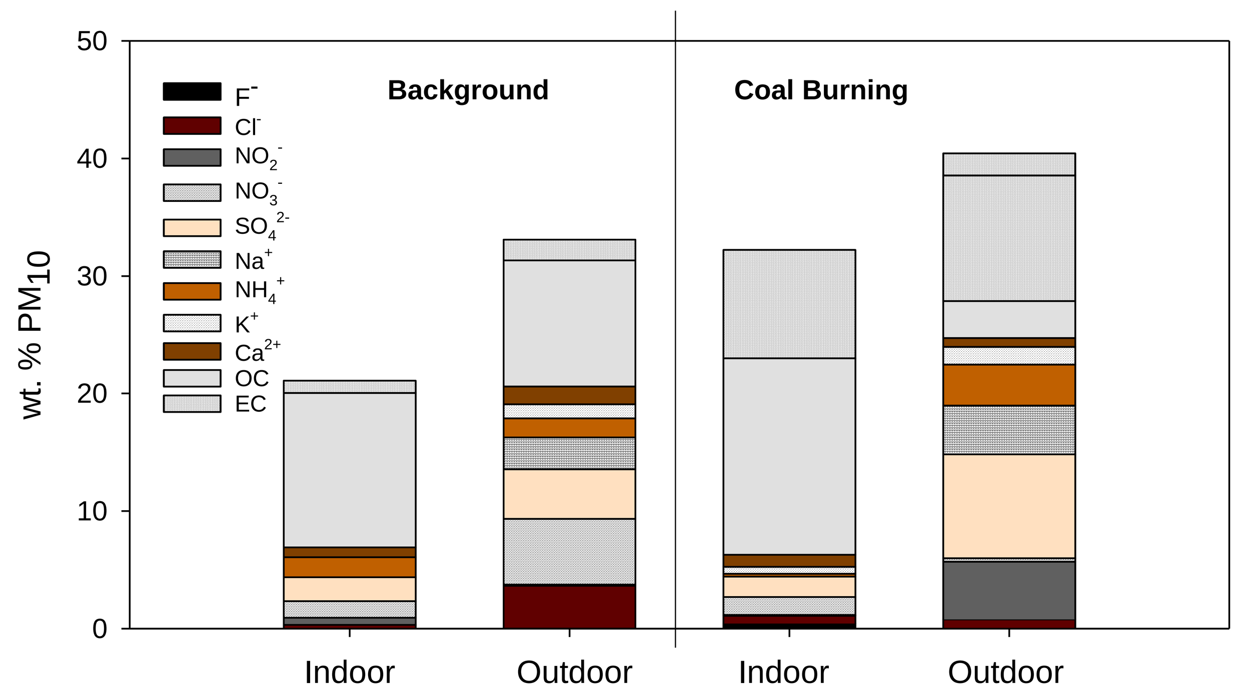


Figure 5. Average PM_{10} chemical composition during coal combustion and without indoor activities (background).

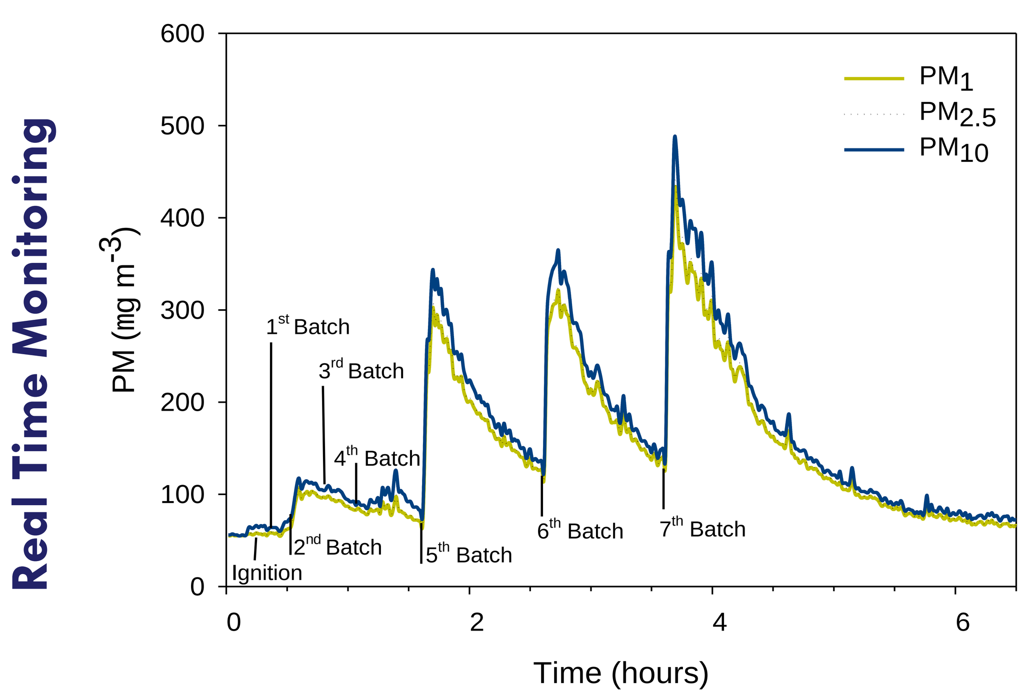


Figure 2. Indoor daily profiles of PM_1, $PM_{2.5}$ and PM_{10} measured indoors during coal combustion (Day 5).

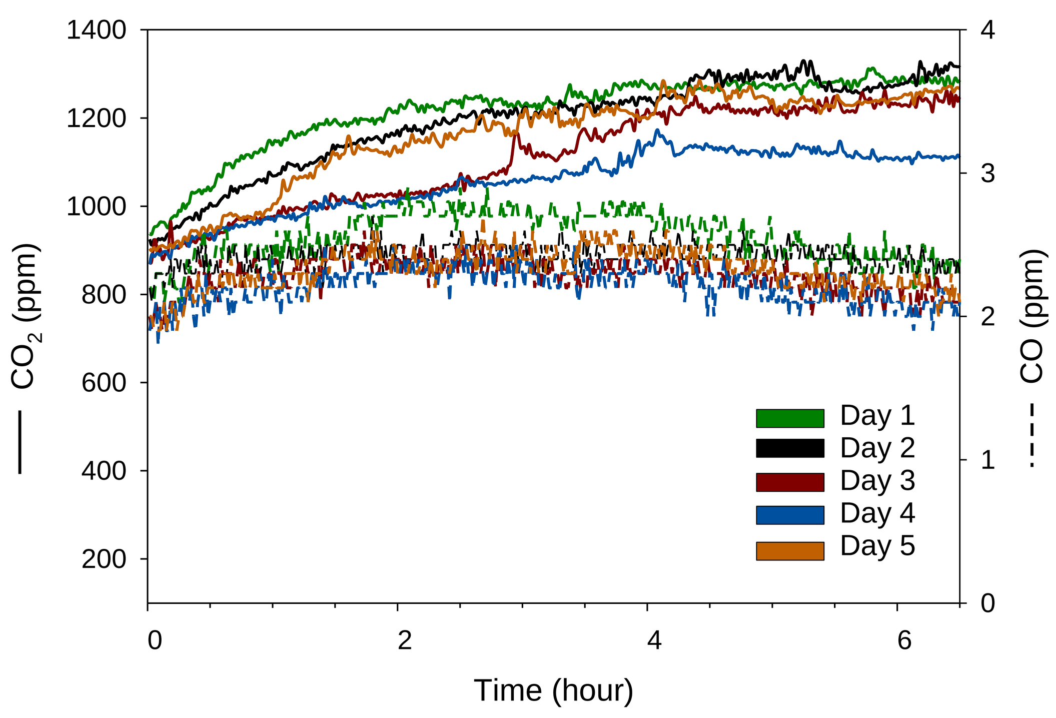


Figure 4. Indoor daily profiles of carbon dioxide and carbon monoxide during coal combustion.

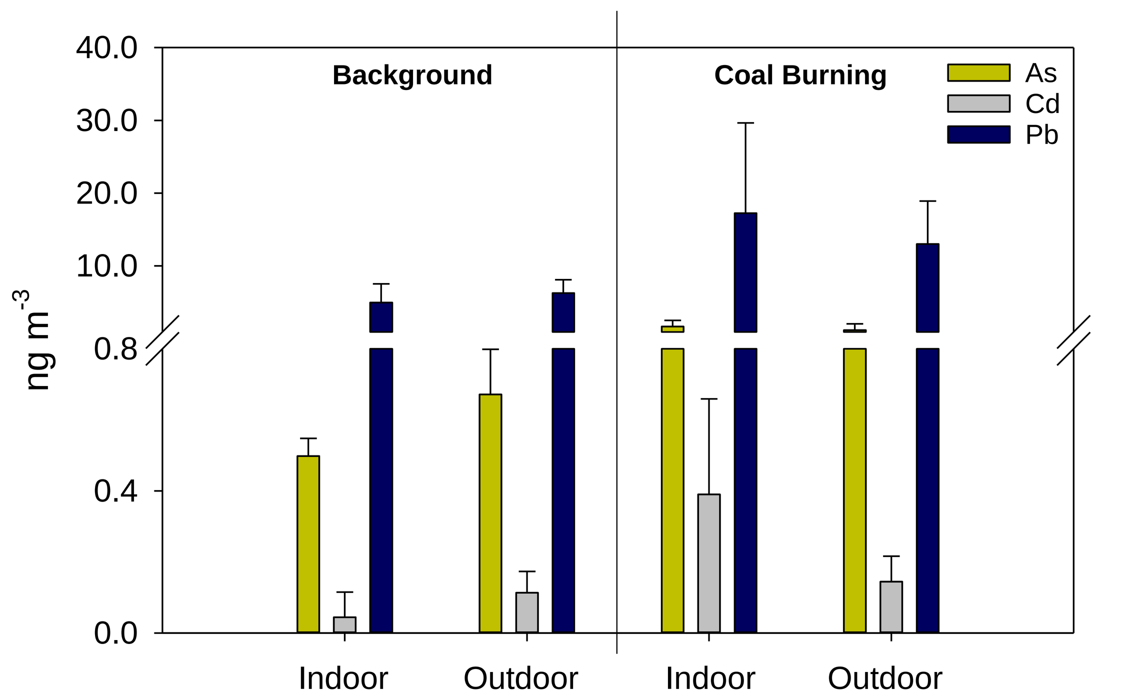


Figure 6. Average concentration of toxic metals during coal combustion and without indoor activities (background).

References

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Kerimray A, Rojas-solórzano L, Amouei M, et al. (2017) Energy Sustain. Dev. 40, 19–30.

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Conclusions:

- The study included simultaneous measurements inside and outside, covering several days in which the combustion conditions were tried to be replicated, and also measurements of the background air in the absence of the source.
- Indoor PM_{10} concentrations increased 1.6 to 8.8 times compared to background air. Daily variability in indoor PM_{10} levels was associated not only with chimney draught, but also with coal burnt.
- The mean PM_{10} I/O ratio was 2.1 ± 1.3 and 0.78 ± 0.06, during coal combustion experiments and background measurements, respectively, confirming the relevance of coal emissions to levels measured indoors.
- The ignition and initial preheating of the stove, as well as fuel refills, generated high PM peaks indoors.
- Indoors, during coal combustion, PM_{10} mass was mainly composed of carbonaceous particles, accounting for 20.7 – 29.8 wt. %. Water-soluble ions represented a small fraction of the PM_{10} mass (5.90 ± 3.70 wt. %) and were dominated by sulphate and nitrate. The indoor concentrations of arsenic, was more than three times higher than those of the background air. Additionally, the indoor concentrations of other toxic and carcinogenic species (such as Pb and Cd) also showed an increase during coal combustion.