

# Emissions from residential combustion of several types of mineral coal

E.D. Vicente<sup>1</sup>, A.I. Calvo<sup>1</sup>, C. Alves<sup>2</sup>, C. Blanco Alegre<sup>1</sup>, R. Fraile<sup>1</sup>

<sup>1</sup> Department of Physics, IMARENAB University of León, León, 24071, Spain

<sup>2</sup> Department of Environment and Planning, CESAM, University of Aveiro, Aveiro, 3810-193, Portugal

Keywords: mineral coal, emission factors, TSP, OC/EC, water-soluble ions.

Presenting author email: edomv@unileon.es

Despite the decreasing tendency in the use of coal for residential heating purposes in Europe (Kerimray *et al.* 2017), coal combustion is still a major source of atmospheric pollutants in several countries (e.g., Lin *et al.*, 2019; Pandolfi *et al.*, 2020). In Spanish cities, such as León, despite the government incentives to replace traditional and old coal-fired stoves and boilers, the use of this fuel for residential heating is still widespread (Blanco-Alegre *et al.*, 2022). Considering that emissions from this source strongly depends on the combustion appliance design, combustion conditions, user practices, and type of fuel, this study intends to investigate the importance of the fuel type on emission of pollutants, covering the expected usage in real households.

In the present work, three types of mineral coal (Table 1) and wood chips from poplar were purchased from local suppliers and burned in a stand-alone cast-iron stove locally acquired. Combustion experiments were designed to mimic realistic household coal burning practices. The combustion procedure was distinct depending on the coal type burned due to fuel properties such as ease of ignition and burning rates. All combustion experiments were initiated igniting the cold appliance with small wood chips and newspaper sheets. Flue gas was sampled from the stack and transported via a heated sampling probe (180 °C) to a Horiba PG350 gas analyser (NO<sub>x</sub>, SO<sub>2</sub>, CO<sub>2</sub>, CO, O<sub>2</sub>) after flue gas drying. The determination of total hydrocarbons was made by a flame ionisation analyser (Signal Model 3010 FID). The flue gas temperature was monitored continuously at the chimney using a K-type thermocouple. The determination of total suspended particles (TSP) in the hot flue gas was carried out following the ISO 9096:2017. TSP sampling was carried out using an automatic isokinetic sampler instrument (DADOLAB ST5 01). After sampling, the filters were dried in an oven (Binder) and reweighted using a microbalance (Kern ABT 120-5 DM). After gravimetric determinations, thermal-optical analysis of TSP filters was performed to obtain the carbonaceous content, organic and elemental carbon (OC/EC). Water-soluble inorganic ions were analysed by ion chromatography. Gaseous and TSP emission factors were calculated using the carbon mass balance method.

Overall, CO<sub>2</sub> accounted for 97.0 ± 3.5 % of the total carbon emitted during coal combustion. SO<sub>2</sub> emission factors were higher for coal A, ranging from 18.1 to 31.8 g kg<sup>-1</sup> fuel burned. Sulphate was the major ionic

component in the TSP samples, regardless of the coal type burned, representing from 0.06 to 24.1 %wt. of the TSP mass. The contribution of total carbon to TSP mass was highly variable depending on the coal burned and combustion stage. For most samples, the carbonaceous components of TSP were dominated by elemental carbon.

Table 1. Proximate and ultimate analysis of coal types used in the combustion experiments.

Proximate analysis	Unit	Coal A	Coal B	Coal C
Moisture	wt.%, as received	3.61	4.53	4.1
Ash	wt.%, dry basis	1.28	6.21	3.15
Volatile matter	wt.%, dry basis	36	11.9	1.89
Fixed carbon*		62.3	81.9	95.0
Ultimate analysis				
C		83.9	85.5	93.5
H		5.42	3.55	1.25
N	wt.%, dry basis	1.66	2.03	0.77
S		0.45	0.31	1.08
O*		7.29	2.4	0.25
Lower heating value	MJ kg <sup>-1</sup>	33.2	32.7	32.7

\* by difference

This work was partially supported by the Junta de Castilla y Leon co-financed with European FEDER funds (Grant LE025P20). It was also in part supported by the AEROHEALTH project (Ministry of Science and Innovation, Grant PID2019-106164RBI00, co-financed with European FEDER funds). The financial support to CESAM by FCT/MCTES (UIDP/50017/2020 + UIDB/50017/2020 + LA/P/0094/2020), through national funds, is also acknowledged.

Blanco-Alegre, C., *et al.* (2022) Contribution of coal combustion to black carbon: Coupling tracers with the aethalometer model. *Atmos. Res.* **267**, 105980.

Kerimray, A., *et al.* (2017) Coal use for residential heating: Patterns, health implications and lessons learned. *Energy Sustain. Dev.* **40**, 19–30.

Lin, C., *et al.* (2019) Wintertime aerosol dominated by solid-fuel-burning emissions across Ireland: Insight into the spatial and chemical variation in submicron aerosol. *Atmos. Chem. Phys.* **19**, 14091–14106.

Pandolfi, M., *et al.* (2020) Long-range and local air pollution: what can we learn from chemical speciation of particulate matter at paired sites? *Atmos. Chem. Phys.* **20**, 409–429.