

## Charcoal Traditional Production in Portugal: Contribution to the Quantification of Air Pollutant Emissions

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**Abstract :** The production of charcoal relies on rudimentary technologies using traditional brick kilns. Charcoal is produced under pyrolysis conditions: breaking down the chemical structure of biomass under high temperature in the absence of air. The amount of the pyrolysis products (charcoal, pyroligneous extract, and flue gas) depends on various parameters, including temperature, time, pressure, kiln design, and wood characteristics like the moisture content. This activity is recognized for its inefficiency and high pollution levels, but it is poorly characterized. This activity is widely distributed and is a vital economic activity in certain regions of Portugal, playing a relevant role in the management of woody residues. The location of the units establishes the biomass used for charcoal production. The Portalegre district, in the Alto Alentejo region (Portugal), is a good example, essentially with rural characteristics, with a predominant farming, agricultural, and forestry profile, and with a significant charcoal production activity. In this district, a recent inventory identifies almost 50 charcoal production units, equivalent to more than 450 kilns, of which 80% appear to be in operation. A field campaign was designed with the objective of determining the composition of the emissions released during a charcoal production cycle. A total of 30 samples of particulate matter and 20 gas samples in Tedlar bags were collected. Particulate and gas samplings were performed in parallel, 2 in the morning and 2 in the afternoon, alternating the inlet heads (PM<sub>10</sub> and PM<sub>2.5</sub>), in the particulate sampler. The gas and particulate samples were collected in the plume as close as the emission chimney point. The biomass (dry basis) used in the carbonization process was a mixture of cork oak (77 wt.%), holm oak (7 wt.%), stumps (11 wt.%), and charred wood (5 wt.%) from previous carbonization processes. A cylindrical batch kiln (80 m<sup>3</sup>) with 4.5 m diameter and 5 m of height was used in this study. The composition of the gases was determined by gas chromatography, while the particulate samples (PM<sub>10</sub>, PM<sub>2.5</sub>) were subjected to different analytical techniques (thermo-optical transmission technique, ion chromatography, HPAE-PAD, and GC-MS after solvent extraction) after prior gravimetric determination, to study their organic and inorganic constituents. The charcoal production cycle presents widely varying operating conditions, which will be reflected in the composition of gases and particles produced and emitted throughout the process. The concentration of PM<sub>10</sub> and PM<sub>2.5</sub> in the plume was calculated, ranging between 0.003 and 0.293 g m<sup>-3</sup>, and 0.004 and 0.292 g m<sup>-3</sup>, respectively. Total carbon, inorganic ions, and sugars account, in average, for PM<sub>10</sub> and PM<sub>2.5</sub>, 65 % and 56 %, 2.8 % and 2.3 %, 1.27 %, and 1.21 %, respectively. The organic fraction studied until now includes more than 30 aliphatic compounds and 20 PAHs. The emission factors of particulate matter to produce charcoal in the traditional kiln were 33 g/kg (wooddb) and 27 g/kg (wooddb) for PM<sub>10</sub> and PM<sub>2.5</sub>, respectively. With the data obtained in this study, it is possible to fill the lack of information about the environmental impact of the traditional charcoal production in Portugal. Acknowledgment: Authors thanks to FCT - Portuguese Science Foundation, I.P. and to Ministry of Science, Technology and Higher Education of Portugal for financial support within the scope of the project CHARCLEAN (PCIF/GVB/0179/2017) and CESAM (UIDP/50017/2020 + UIDB/50017/2020).

**Keywords :** brick kilns, charcoal, emission factors, PAHs, total carbon

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