Contribution of residential biomass combustion to air pollutant emissions

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Abstract
The aim of this study was the characterisation of particle emissions from residential wood combustion of common woods grown in Portugal. This research tried to understand the differences that the burning appliance (fireplace versus woodstove) and the combustion temperature (cold and hot start) have on emissions. Pinus pinaster (Maritime pine), Eucalyptus globulus (Eucalypt), Quercus suber (Cork oak), Acacia longifolia (Golden wattle), Quercus faginea (Portuguese oak), Olea europea (Olive), Quercus ilex rotundifolia (Holm oak) and Briquettes produced from forest biomass waste were used in the combustion tests. Determinations included fine particle emission factors (PM$_{2.5}$), carbonaceous content (OC and EC), detailed identification and quantification of organic compounds, water soluble ions (Na$^+$, NH$_4^+$, K$^+$, Mg$^{2+}$, Ca$^{2+}$, Cl$^-$, NO$_3^-$ and SO$_4^{2-}$) and 67 trace elements. Fine particle emission factors from the woodstove were lower than those from the fireplace. For both combustion appliances, the OC/EC ratio was higher in “cold start” tests. About 50% of the PM$_{2.5}$ mass was composed of organic carbon. The chromatographically resolved organics included n-alkanes, n-alkenes, PAHs, n-alkanals, ketones, n-alkanols, terpenoids, terpeneoids, phenolic compounds, phytosterols, alcohols, n-alkanolic acids, n-dicarboxylic acids, unsaturated acids and alkyl esters of acids. The water-soluble ions accounted for about 1 to 14% of the PM$_{2.5}$ mass. Trace elements represented 0.4 to 2.5% of the PM$_{2.5}$ mass with an average total emission of 110±64 mg kg$^{-1}$ of wood burned.

Introduction
Emissions from the woodstove combustion are being seen as an important contributor to the airborne particulate matter. This study was focused on domestic wood combustion. The aim was to obtain comprehensive organic and inorganic compound source profiles for PM$_{2.5}$ emitted from burning of Maritime pine, Eucalypt, Cork oak, Golden wattle, Portuguese oak, Olive, Holm oak and Briquettes in domestic appliances. These eight fuel types were chosen because they are the most used in Portugal. So only softwood studied was Maritime pine, the other species were hardwood.

Experimental work
The burning tests were carried out at the Department of Environment, University of Aveiro, combustion facility [1]. Two types of residential biomass combustion appliances were selected for the source tests: a) a cast iron wood stove (Solizama, model Sahara) and b) a traditional Portuguese brick open fireplace (Figure 1).

Analytical methods
- PM$_{2.5}$ - Gravimetric analysis was performed to determine the amount of particulate matter.
- EC and OC - The carbonaceous content (elemental and organic carbon) of particulate matter in quartz fibre filters was analysed by a thermal-optical technique [2].
- Organic compounds - A detailed identification and quantification of organic compounds was made by gas chromatography-mass spectrometry [3].
- Soluble inorganic ions - Small parts of the filters were extracted with ultra pure Milli-Q water and were determined by ion chromatography.
- Trace elements - Inductively coupled plasma mass spectrometry (ICP-MS) analyses performed on the supernatant solutions using an Agilent instrument (7500 series).

Results
This work provided detailed information on organic composition of smoke particles from residential combustion of the most prevalent Portuguese woods.

Carboanaceous content
Organic carbon contributed to about 50% of the fine particle mass in the emissions from every wood species studied in both burning appliances. Maritime pine produced the highest EC emissions (fireplace and woodstove), while Holm oak and Briquettes presented the lowest EC content in PM$_{2.5}$ from fireplace. For woodstove, the Golden wattle smoke encompassed the lowest EC emissions. In general, high OC/EC ratios were obtained for all species, especially in the fireplace. The lowest OC/EC ratios were obtained for the maritime pine.

Conclusions
Since the distributions and abundances of the biomass smoke constituents are dependent on combustion temperature, the emission profiles obtained in this study should not be used as absolute but as relative chemical fingerprints for residential wood burning. The comparison of emissions from this study with literature data showed significant differences between the various types of combustion equipment, especially old type residential appliances versus modern woodstoves and boilers with higher combustion efficiency.

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References