Residential wood combustion: links between ion content, organic and elemental carbon and aerosol size distributions

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The demand of wood for heating purposes has substantially increased in the last few years. However, biomass burning has been identified as a major source of atmospheric pollution (Puxbaum *et al.*, 2007).

Several studies have been carried out for the determination of biomass burning emissions. However few of these studies represent the southern European reality and Portugal in particular. On the other hand, most studies do not analyse the evolution of particle size distribution throughout the combustion cycle. These studies are of high relevance as they can help understand and point out critical stages or intervals of emission of particulate matter and help in the development of equipment's or techniques that can prevent or reduce the emission during these stages.

The monitoring of particle size distributions is important in order to evaluate the impacts in different aspects, such as climate, but especially health, due to the toxicology associated with particulate matter from wood burning (Leskinen *et al.,* 2014).

An important variability has been observed for particle number emission factors and geometric mean diameters. Thus, Johansson *et al*. (2008) found values ranging from 0.3 $x10^{13}$ to $102x10^{13}$ particles per MJ of fuel in a study for different appliances. They also found geometric mean diameters ranging between 50 and 210 nm, always showing a unimodal distribution.

The objective of the present study is to characterise the ion content, size distribution and particle number emission factors during the combustion of three typical Portuguese woods – *Pinus pinaster* – pine –, *Eucalyptus globulus* – eucalypt – and *Quercus suber* – cork oak – used commonly as fuel in residential combustion devices.

Two different appliances were used: a) traditional brick Portuguese open fireplace and b) cast ironl stove. Both are manually operated in batch mode, but the stove has a handheld for combustion air control, also manually operated. The devices are equipped with a vertical exhaust duct (chimney) with 0.20 m internal diameter and 3.30 m height. Several parameters, such as the weight of the fuel in the burning fixed bed at the grate, the temperature at several points of the experimental infrastructure, the air flow rate entering in the combustion chamber (for the stove) or at the exit of the chimney (for the fireplace), are continuously monitored throughout each combustion cycle (Calvo *et al*., 2014).

Wood was cut into logs of 0.3 to 0.4 m in length with total mass of fuel per test of 1.8 to 2 kg. Each combustion cycle lasted between 45 to 60 minutes.

The flue gas from both appliances was collected in a dilution tunnel (11 m length and 0.20 m internal diameter) located downstream of the chimney. Particulate matter was collected under isokinetic conditions, onto quartz fibre filters. The sampling points were located at ~10 m downstream of dilution tunnel entering. Aerosol samples were collected by a Venturi system and redirected towards a second dilution tunnel of 1.13 m length and 0.07 m internal diameter. An optical particle counter (PCASP-X) was used, for the continuous monitoring of particle size distributions in the flue gas.

Ion chromatography was used to determine major soluble inorganic ions (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^-, PO_4^{3-} and SO_4^{2-}).

Preliminary data analysis showed ion concentrations between 1 – 7% of PM_{10} mass for pine and eucalypt, respectively, in the woodstove. Potassium, a classical tracer for biomass burning, presented the highest concentration either for eucalypt or cork oak in the woodstove. Relationship between ion concentrations and particle number and size registered throughout the combustion process will be established.

Aerosol size distribution data analysis showed an increase in particle number with increasing temperatures, while the mean geometric diameter decreases with high temperatures.

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