AIRUSE LIFE+: Biomass burning emission factors and chemical profiles in Southern Europe

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Keywords: PM emissions, residential combustion, OC/EC, organic tracers, potassium.
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Residential wood combustion is now recognised as a major particulate matter (PM) source in many countries. The combustion appliances in use today provide variable combustion conditions resulting in large differences in the characteristics of the emitted particles. The purpose of this research is focused on fulfilling the need for detailed characterisation of emission profiles resulting from residential combustion of the most prevalent biofuels in Southern Europe. This will contribute with new data to: (i) improve emission inventories, (ii) update databases for source apportionment studies, and (iii) adopt air pollution control measures.

The most prevalent wood species in Southern European countries were burned in common manually fed household appliances: a fireplace, a conventional cast iron stove and an eco-labelled woodstove. Emissions from these devices where compared to those from the combustion of different types of pellets and 3 agro-fuels (olive pit, shell of pine nuts and almond shell) in an automatic pellet stove. Analysis of the wood smoke included organic and elemental carbon (OC/EC) content, ionic and elemental composition, and organic speciation.

On average, the PM emission factors were 1.85±0.91, 8.05±3.05 and 12.59±5.88 g/kg of biofuel (dry basis) for the eco-labelled stove, traditional stove and fireplace, respectively. Particle emissions from the automatic pellet stove ranged from 0.49±0.06 (pellets with EN-Plus label) to 3.12±0.44 (olive pit) g/kg (dry basis). In the fireplace and the old type stove, OC dominated the emissions, while more efficient combustion in the eco-labelled and pellet stoves contributed to 1.3 to 4.7-fold higher EC relative fractions in PM. The pellet stove presented more variable EC particle mass fractions, ranging from 3% (olive pit) to 47% (shell of pine nuts). The EC-to-total carbon (TC=OC+EC) ratios were, on average, 0.076, 0.164, 0.413 and 0.400 for the fireplace, traditional woodstove, eco-labelled stove and pellet stove, respectively. An increase in the ratios with increasing combustion temperature was generally observed.

Particles generated by low combustion temperatures (such as those observed in the fireplace and the traditional woodstove) are characterised by a low content of inorganic constituents. The water-soluble ions accounted for about 1 to 14% of the PM mass emitted by these two combustion appliances. Trace elements represented 0.4 to 2.5% of the PM mass with an average total emission of 110±64 mg/kg of wood burned. Inorganic constituents may account for more than 50% of the PM mass emitted from more modern and efficient combustion equipment. The potassium content of the fine particle emissions from pine wood was much lower than in the smoke of other species. This difference may be important if potassium is used as a tracer for conifer and hardwood smoke particles.

The major organic components in particles from biomass burning were anhydrosugars, in particular levoglucosan, acids and aliphatic compounds. Retene was the dominant aromatic hydrocarbon found in the softwood smoke, whilst it was present at very small levels in the hardwood combustion emissions. Guaiacyl, like vanillic acid, and synapyl compounds were identified in softwood smoke, whereas hardwood burning contributed mainly to the formation of syringyl compounds, such as syringic acid. Stigmasterol was only present in the smoke of hardwood species; thus, this compound may be pointed out as a potential tracer for smoke from deciduous trees. β-sitosterol has a great expression in the smoke of softwood species.

As observed for PM, the lowest benza[a]pyrene (BaP) emission factors were registered for the pellet stove. The lowest emitting wood species generated more than 8 times higher BaP concentrations than pellets. This study shows that the flue gas from modern small scale heating systems, such as the eco-labelled stove, could produce elevated BaP emissions, especially during the combustion of conifer logs. These resinous woods are characterised by higher burning rates, which result in very hot flames and sudden drops of the O_2 concentration, leading to higher PAH emissions.

The results of the present study suggest that differences in the source profiles between wood types and combustion appliances merit consideration in source apportionment calculations using either organic or inorganic tracers.

This work was funded by the European Commission thought the AIRUSE (LIFE11 ENV/ES/000584) project. Cátia Gonçalves and Ana Vicente acknowledge, respectively, the PhD and Postdoc grants SFRH/BD/36540/2007 and SFRH/BPD/88988/2012 from the Portuguese Science Foundation, as well as the financing programme POPH/FSE.