The effect of wood fuel species on particulate and gaseous emissions from a wood stove

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Residential wood combustion (RWC) is a very important contributor to air quality worldwide, both in developed and developing countries (e.g. Sigsgaard *et al.,* 2015). In EU, its' relative importance is still increasing because industrial emissions and traffic pollutants are strictly restricted by legislations. RWC aerosol includes several particulate and gaseous compounds which are important particularly in terms of climate and health perspectives. Extremely harmful emissions are ultrafine particles, heavy metals, black carbon (BC) and polycyclic aromatic hydrocarbons (PAHs) (Tissari *et al.,* 2015). In this study, six batches of different wood species (birch, beech, pine and alder) with birch for the first batch were combusted in a wood stove. Data from the last four batches were analysed to observe the impact of various fuel types on the production of particulate and gaseous emissions from the stove. To a feasible extent, same protocol for each experiment was applied and tests were repeated two times.

The experiments were conducted in the small-scale combustion simulator (SIMO) at the University of Eastern Finland (http://www.uef.fi/en/web/fine/simo). The SIMO is a facility that allows testing of various small-scale wood combustion appliances in near to real-life conditions. Gaseous emissions were measured with separate gas analyzers (ULTRAMAT 23, Siemens) and with a Fourier Transform Infrared analyzer (FTIR, Gasmet Technologies Ltd.). For particle measurements, a two-phase dilution system was used (Tissari et al., 2019). The dilution ratio (DR) was controlled and was set to a constant value of 90. Concentrations from particle measurements were performed with several on and off-line instruments.

Preliminary results show that both the gaseous and particulate mass emissions varied in the combustion of all four fuel species (Table 1), even if the same fuel, varied concentrations of these emissions in four different batches are clearly observed (Fig. 1). Largest variation of emissions was observed in Alder wood (e.g. $PM_{2.5}$ = 20.1 to 69.3 mg/Nm^3), while the smallest variation of emissions was observed in birch wood; (e.g. $PM_{2.5}$ = 11.6 -27.5 mg/nm^3) (Table 1 and Figure 1).

Table 1: Concentrations (in mg/nm^3, 13% O_2) of emission components for different fuel species

Fuel species	NO	CO	THC	$PM_{2.5}$	BC
PINE	77.7	2081	50.7	32.2	19.7
SPRUCE	94.0	4672	163.7	46.5	13.6
ALDER	122.8	2821	105.1	48.6	19.5
BIRCH	88.7	1239	20.1	22.3	13.6

On average, all emissions were the lowest with birch wood (except of nitrogen oxide (NO), that was slightly higher than with pine wood), whereas spruce produced the highest CO and THC concentrations. Interestingly, it produced low BC concentration, at same level as birch. This study shows that the different fuel species produce different level of gaseous and particulate emissions, thereby, referring to the chemical content of the wood is one determining factor for generating the emissions. However, several other parameters such as air to fuel ratio, physical size of the wood logs, and the moisture contents may also have the impact on emission formation in the stove.

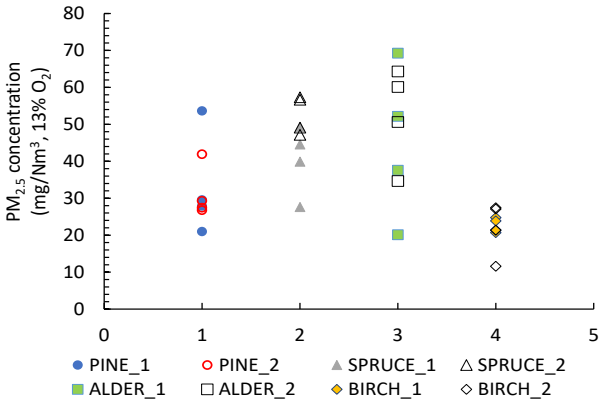

Figure 1: Effect of different fuel species on PM2.5 emission

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