

# Ash behaviour and emission formation in co-combustion of wood and two agricultural fuels

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Keywords: biomass combustion, co-combustion, agricultural fuel, ash.

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Utilizing annual biomass in heat and energy production is an interesting option considering the reduction of CO<sub>2</sub> emissions. Typically, volumes of agricultural residues are too low for large-scale utilisation, but local small-scale combustion is considered as a cost-effective solution. Combustion of field biomass would be one possibility for countries that have limited availability of woody biomass and large yield of agricultural residues.

The drawback of field biomass is high concentration of potassium, chlorine and sulphur, which may cause high mass emissions of PM and formation of corrosive deposits on heat exchanger surfaces. It is known that chemical composition of the fuel has a strong effect on the release of alkali metals (Tissari et al., 2008). Vaporized alkali metals form alkali sulphates and chlorides, which condense and form fine particles. Understanding the behaviour of ash forming elements in combustion is important considering the emissions, fouling of the combustion device and sintering of ash, as well as utilization of the ashes (fertilizers, soil enrichment).

In this work, the fine ash (PM<sub>1</sub>) and bottom ash compositions were studied in co-combustion of wood chips with reed canary grass and wood chips with straw. The mixing ratio of wood chips and reed canary grass (WC+RCG) was 78/22 (wt %) respectively. With wood chips and straw (WC+S) two batches were mixed at proportions of 67/33 and 77.5/22.5 (wood chips/straw, wt %). All fuels were analysed for moisture and ash content, heating values and ash-forming elements.

The burner utilised in the experiment was a 40 kW moving step-grate stoker burner. Further details of combustion reactor are presented by Kettunen et al. (2011).

Gaseous compounds (NO<sub>x</sub>, O<sub>2</sub>, SO<sub>2</sub>, CO, CO<sub>2</sub>) were measured from undiluted flue gas with FTIR. For particle sampling flue gas was diluted in two steps. First dilution was done with a porous tube diluter (PRD) and further dilution with an ejector diluter (ED). The average total dilution ratio (DR) varied between 32 and 46. Particle size distribution was measured from diluted sample with an electric low pressure impactor (ELPI). PM<sub>1</sub> samples were collected on Teflon filters. Concentrations of organic, elemental and carbonate carbon (OC, EC and CO<sub>3</sub>) were analysed from quartz filters positioned after pre-impactor (1 μm). Samples were also taken for TEM-EDS and XRD analyses.

Primary combustion air was fed through the grate and secondary combustion air from the top of the burner (approx. 13 cm above grate). Combustion air flows were measured continuously with hot-wire sensors.

Co-combustion of wood chips and reed canary grass produced similar fine fly ash emission levels than burning pure wood whips. The PM<sub>1</sub> emissions varied between 17 and 24 mg/MJ, whereas good combustion of wood chips produced emissions between 12 and 22 mg/MJ. The fine fly ash emissions from co-combustion of wood chips and straw on the other hand were 7.5 to 18-fold compared to wood combustion. In addition, the EC emission increased significantly due to lower combustion efficiency caused by the high ash content and inhomogeneous fuel quality.

Reed canary grass had slightly lower release percentage of potassium in fly ash, but clearly higher release of chlorine compared to straw, where Cl is released as HCl in gas phase. Also bottom ash retention percentage of potassium was higher in reed canary grass combustion. Molar ratio of K/Cl in fuel was observed to have negative correlation with SO<sub>4</sub><sup>2-</sup> in fly ash as well as total fine fly ash emission.

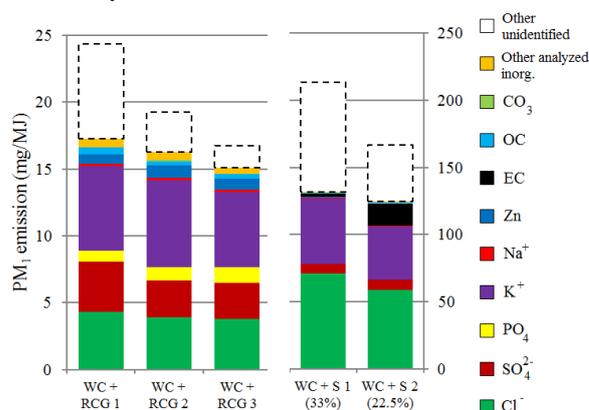


Figure 1. PM<sub>1</sub> emissions and their composition (notice the tenfold scale in straw co-combustion).

In this experiment reed canary grass turned out to be more suitable fuel for co-combustion with wood chips than straw.

The authors thank the Finnish Funding Agency for Technology and Innovation and the strategic funding of the University of Eastern Finland (Sustainable Bioenergy, Climate Change and Health) for financial support.

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