GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

HelmholtzZentrum münchen
German Research Center for Environmental Health

Sampling and analysis of biomass combustion products

Torben Seidel[1], Jürgen Orasche[2], Hans Ruppert[1], Jürgen Schnelle-Kreis[2] and Ralf Zimmermann[2,3]

[1]Dept. of Sedimentology and Environmental Geology, Geoscience Center, University of Göttingen, Goldschmidtstrasse 3, D-37077 Göttingen, Germany
[2]Institute of Ecological Chemistry, Helmholtz Zentrum München, D-85764 Neuherberg, Germany
[3]Analytical Chemistry, University Rostock, Dr.-Lorenz-Weg 1, D-18051 Rostock, Germany

Background and Objective

The application of biomass as an electricity and heat supplier may play an essential future role due to the greenhouse effect, the shortage of fossil energy sources and the striving autonomy from fossil fuels. The growing contribution of biomass to heat supply may have an adverse influence on the acceptance due to the arising emissions and hence possibly cause health problems. Concerning emission it is essential to have a reliable sampling of the particulate organic and inorganic matter in the exhausted gas.

Tools and Methods

Emissions from five different small-scale furnaces were sampled from the dilution tunnel on quartz fiber filters in a heated innovative 150mm filter holder consisting of PTFE. The grain size distribution is measured with an ELPI. The emissions during the starting and flaming phase were collected separately. The 150mm filter was subsequently portioned for the organic and inorganic analysis. The separation was carried out with an innovative V-formed cutting tool made of titanium with a 30° angle between the edges. The inorganic analysis were carried out with $^{11}/_{12}$ and the organic analysis with $^{1}/_{12}$ of the material. The material for the inorganic analysis were digested with HF (excluding the fly ashes due to the filter material), $HClO_4$ and HNO_3 in closed PTFE vessels. The subsequent inorganic analysis were carried out with an ICP-MS and an ICP-OES. The sampling position in the combustion system enables the condensation of organic material. The organic components are analyzed directly from filter matrices with In-Situ Derivatization Thermal Desorption Gas-Chromatography Time-Of-Flight Mass Spectrometry (IDTD-GC-TOFMS).
The sampled material does not only comprise the fly ash but also the fuel and the grate ash. Based on input and output data of inorganic elements it is possible to calculate fluxes normalized to e.g. energy units. In contrast to the usually applied 45mm filter and filter holder the large diameter and the material of the new filter holder and the filter itself ensures enough sample material for our organic and inorganic analysis, guarantees good detection limits and a low background concerning contaminating elements.

Fig. 1: Dilution tunnel with the affixed 150 mm filter holder.

Fig. 2: 150 mm filter holder composed of PTFE.

Fig. 3: V-formed cutting tool composed of titanium.

Fig. 4: 150mm quartz fiber filter with blanked out portion for organic analysis.

Results

- Organic composition shows strong dependency on combustion conditions and on precipitator efficiency. For example a decrease of filtering efficiency shows not only an increase of dust concentration but even a rise of biomass marker levoglucosan concentration compared to other organic components (Fig. 7, 8).
- Levoglucosan often seen as organic marker for biomass combustion vary in concentrations depending strongly on combustion conditions. But together with potassium it is the link to ambient aerosol.
- Beside further elements, the input data especially for the environmentally or health relevant elements Cd, Zn, Sn, Tl, Pb, Bi and Sb of burned wood or straw are not in accordance with the output data (ash, grate and fly ash) presumably these elements left the chimney in a gaseous state. This takes effect in all surveyed combustions.
- Fluxes normalized to energy units can be applied to compare different facilities, fuels, burning conditions, etc.

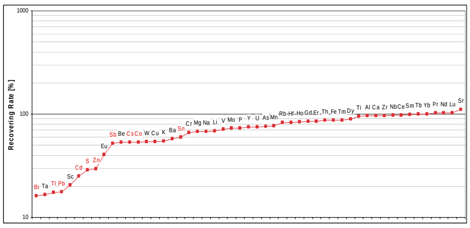

Fig. 5: Recovering rate [%] for a range of elements (Pellet stove, 13 kW, spruce pellets).
Input data: amount of an element delivered by the the fuel.
Output data: sum of the amount of an element in the grate ash, in the ash of an internal heat exchanger and in the fly ash.

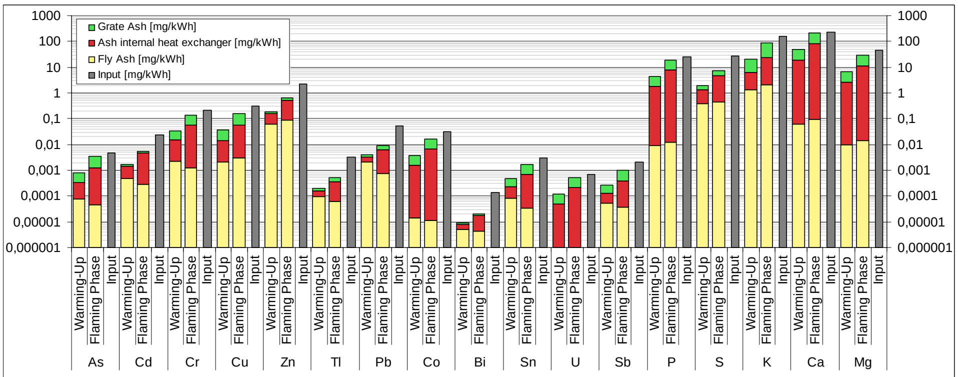

Fig. 6: Comparison of input- and output-fluxes of a range of elements. Compared are the warming-up and flaming phase of a 13kW pellet stove.

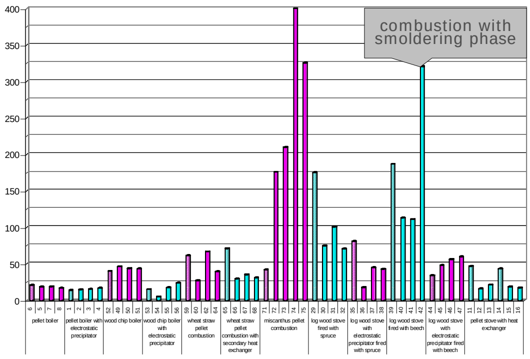

Fig. 7: Comparison of different residential heating systems. Determination of dust loading (mg Nm^{-3}) was done gravimetrical by sampling with 150 mm quartz fiber filters. Striped columns show values from starting phase. This means heating up of cold systems (oven and chimney).

Outlook

- Gravimetric determination of particulate matter combined with fast inorganic and organic analyzing methods will help improving combustion conditions.
- Chemical composition is needed for assessing health risks. Further studies are planed to combine chemical and toxicological tests.
- The nonconformity between input and output makes a careful sampling inevitable.
- Sampling on a 150mm filter is a good compromise between handling and sample volume.

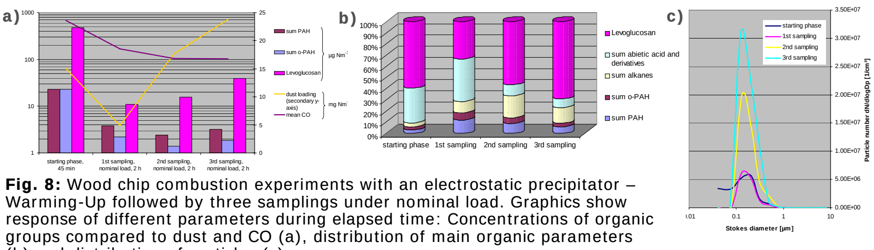

Fig. 8: Wood chip combustion experiments with an electrostatic precipitator – Warming-Up followed by three samplings under nominal load. Graphics show response of different parameters during elapsed time: Concentrations of organic groups compared to dust and CO (a), distribution of main organic parameters (b) and distribution of particles (c).

Acknowledgements

The study was supported by the Federal Ministry of Science and Culture, Lower Saxony, Germany.

Universität Rostock · HelmholtzZentrum münchen · JOINT MASS SPECTROMETRY CENTRE · www.jmsc.de
HELMHOLTZ ASSOCIATION
GZG
GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN · IZNE
www.bioenergie.uni-goettingen.de