INDUSTRIAL PILOT PROJECT

X-ray Absorption Spectroscopy for speciation of hazardous metals in ash from waste incineration – Critical knowledge for recycling

THE INDUSTRIAL CHALLENGE

Today, a considerable amount of household and commercial waste that cannot be reused or recycled is incinerated with energy recovery resulting in large streams of fly and bottom ash. Fly ash most often goes to landfills, while bottom ash has excellent properties as ground construction material, such as for building of roads. However, it must be secured that its use poses no environmental risk. For Cu and Zn, the chemical form/speciation determines the ecotoxicity and some chemical forms are therefore regulated. However, no simple methods exist to identify the chemical speciation of the trace metals in the ash and if not known, a worst scenario is applied - preventing the use of bottom ash. Thus, it is crucial to know the chemical speciation of Cu and Zn in the bottom ash to secure a correct classification and an effective use of resources. For fly ash, the chemical speciation is relevant when evaluating the possibilities for extracting trace metals.

Figure. The storage of processed ash at SYSAVs facility at Spillepengen, Malmö

WHY USING A LARGE SCALE FACILITY

The low concentrations and extremely complex ash matrix make it not possible to use traditional lab-based methods for analysing chemical speciation. Synchrotron-based X-ray absorption spectroscopy (XAS) has been identified as one promising method and in the future, the BALDER beamline at MAX IV will provide possibilities for high throughput measurements.

HOW THE WORK WAS DONE

Samples from both bottom and fly ash were collected from five Swedish facilities. After a pre-study at the BALDER beamline using both XANES (X-ray absorption near edge structure) and EXAFS (Extended X-Ray Absorption Fine Structure), the focus was on XANES. The absorption edge of Zn, Cu, and Pb was scanned for in total 16 samples. The project also included building up an open library of reference materials – which is critical for interpreting the XANES results. The probable chemical speciation of Cu, Zn and Pb in ash was determined using Linear Combination Fitting (LCF) of the references to the ash spectra.

Figure. The project team from Fortum Waste Solutions, Sysav and NOAH with research support from RISE, Chalmers Technical University and MAXIV. Also, representatives from Stena and EON joined at MAXIV. Photo: Stena Metall

THE RESULTS AND EXPECTED IMPACT

We could to a large extent explain the XANES spectra using a subset of reference compounds, however, for some ashes additional reference materials are still missing in order to make a full determination of the speciation. A number of questions were addressed such as differences between (i) bottom vs fly ash, (ii) facilities, (iii) before and after storage, and (iv) after processing of the ash. The requirement for a library containing all relevant reference spectra is identified as a limitation of the method when used for analysing a broad range of ashes, but when in place, the method has high potential to be used for determining the speciation of trace metals in ash. The results are summarized in a paper submitted to J. Waste management.

Contacts: Thomas Von Kronhelm – Fortum Waste Solution AB, Thomas.VonKronhelm@fortum.com
Jenny Rissler – RISE Research Institutes of Sweden, jenny.rissler@ri.se

Vinnova's project No: 2018-03254 **Duration:** November 2018 – April 2020

Funded by Sweden's Innovation Agency, Vinnova, in order to build competence and capacity regarding industrial utilisation of large-scale research infrastructures such as MAX IV and ESS.