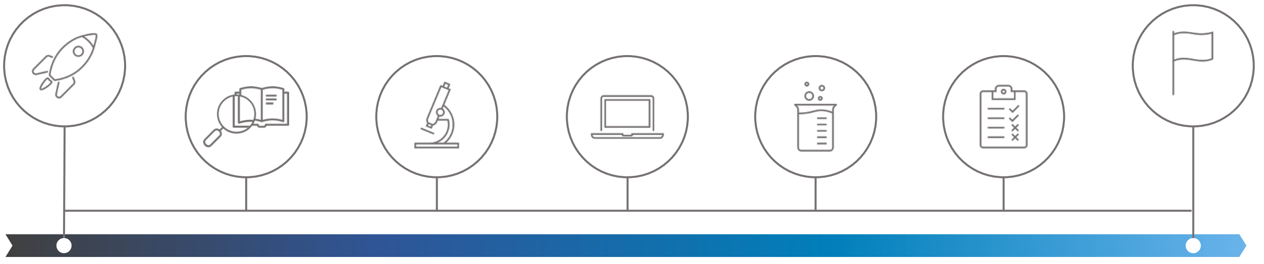
Hydro Stäube

Hydrometallurgische Rückführung von versorgungskritischen Metallen aus Stäuben der Eisen- und Stahlindustrie

Hydrometallurgical recovery of supply-critical metals from dusts of the iron and steel industry

The current research project HydroStaeube analyses various hydrometallurgical leaching steps or combinations thereof for the treatment of steel mill dusts. Most dusts from metal production undergo pyrometallurgical treatment in high-temperature processes. In general, these involve the addition of carbon carriers and hence contribute to CO_2 emissions. Metals contained in the scrap material are partly transferred to the dusts of the steel mill. To return these to the supply chain in terms of circular economy, sustainable processes are required to be climate neutral, resource-saving and energy-efficient. Subsequently, the HydroStaeube method should also allow the recovery of other dusty residues produced in steel mill processes in best case which currently lack a specific treatment process.



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COMPREHENSIVE CHARACTERIZATION OF EAF DUSTS

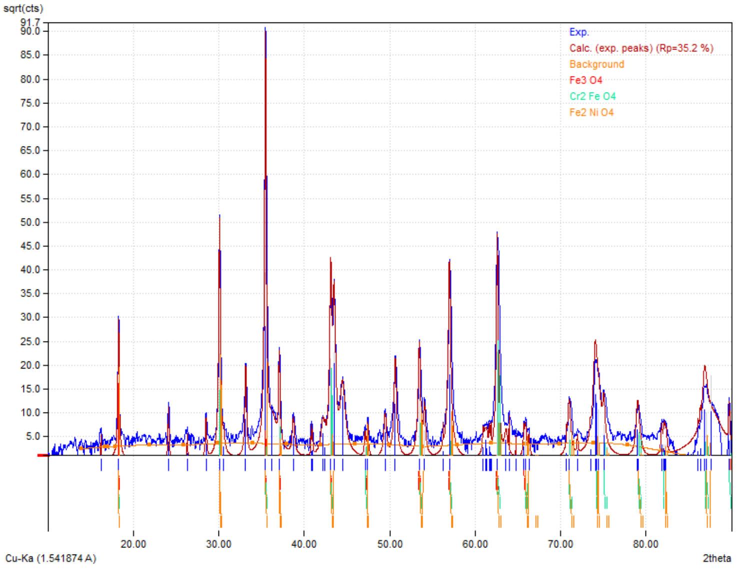

Figure 1: XRD analysis of the valuable metal content

The initial phase of the experimental part for the recovery of valuable metals, such as Zn, Cr and Ni via a targeted hydro-metallurgical approach included an acid variation campaign. The fundamental base for the extraction experiments was formed by an in-deep characterization of five different available dusts from stainless steel production (taken from the electric arc furnace). For this purpose, the valuable metal content was determined by chemical analysis (ICP-OES, XRF) and the mineralogy was determined by XRD (Figure 1).

MORPHOLOGICAL ANALYSIS AND LEACHING EXPERIMENTS

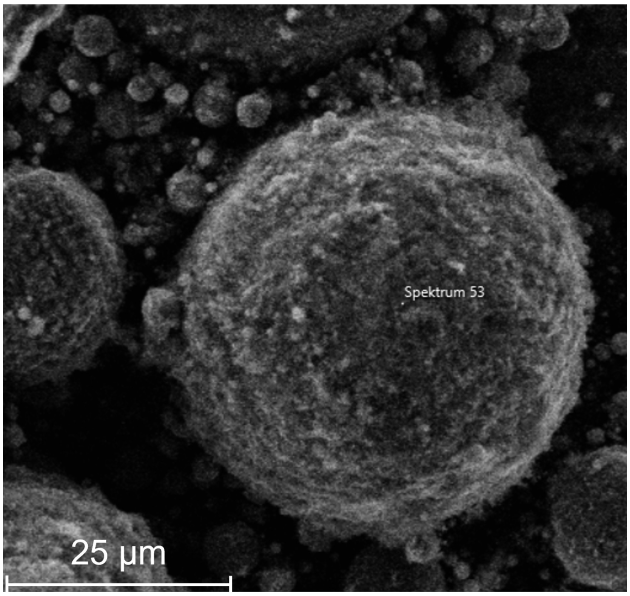

Figure 2: EDX analysis

The morphology was also analysed using a scanning electron microscope equipped with EDX measurement (Figure 2).

The purpose of the leaching experiment series was to examine the leachability of metals and mineral fractions, from the investigated dust from steel production, via five distinct acids (hydrochloric-, sulphuric-, nitric-, acetic-, and citric acid). The examined parameters revealed that hydrochloric acid displayed superior and promising characteristics when compared to the other acids.

EXPERIMENTAL SETUP

Moreover, the utilized experimental setup (Figure 3) was optimized for future campaigns based on the experience gained. This new experimental design incorporates a double-walled reaction vessel for improved heat exchange and accurate control, and a lid with a reflux condenser to prevent excessive loss of leach liquor by evaporation during the current ongoing parameter variation, including further increased temperature regimes. The current ongoing experiments focus on the leaching medium HCl and it is expected that the adapted experimental setup will allow even more accurate mass balances to be produced.

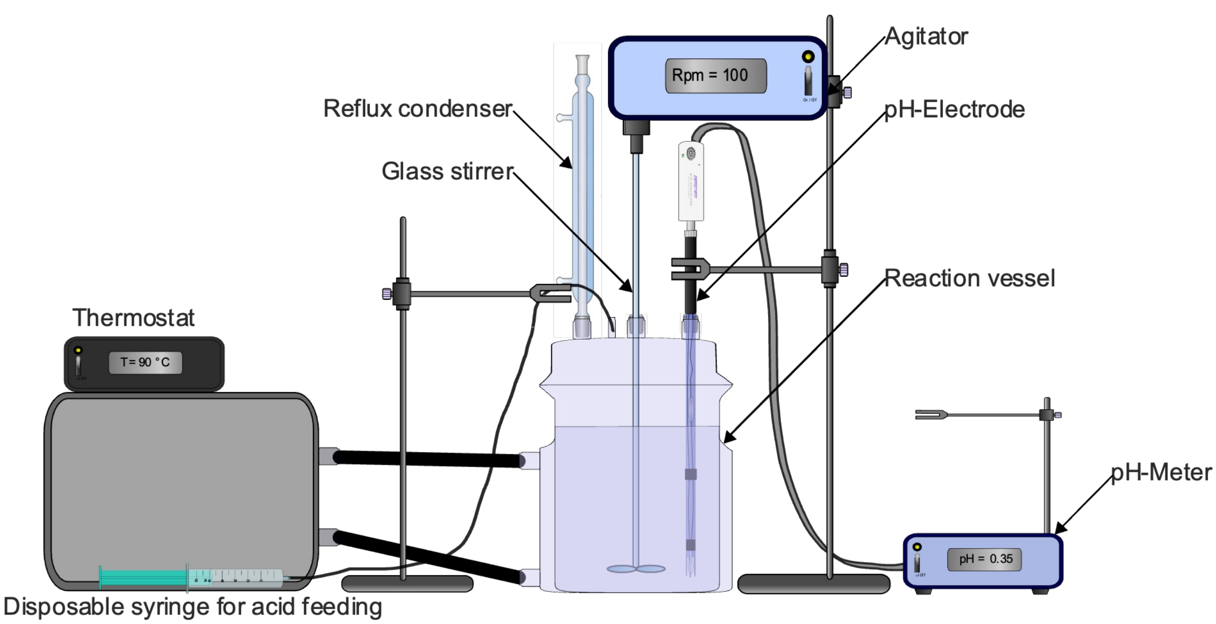

Figure 3: Experimental setup for future campaigns

DUST EMISSIONS

In contrast to other waste streams like end-of-life vehicles or batteries, there is no European data collection of arising steelmaking dust amounts or their chemistry. More in detail, parts of them are internally recycled and material streams with high contents of valuable elements are often sold to recycling companies. In general, the production capacities of hot metal as well as of finished steel in EU countries are available and additionally, there are annual statistical data divided by product categories. Furthermore, the input rates of recycled elements are registered. As mentioned above, the chemical compositions of steelmaking dusts are not published.

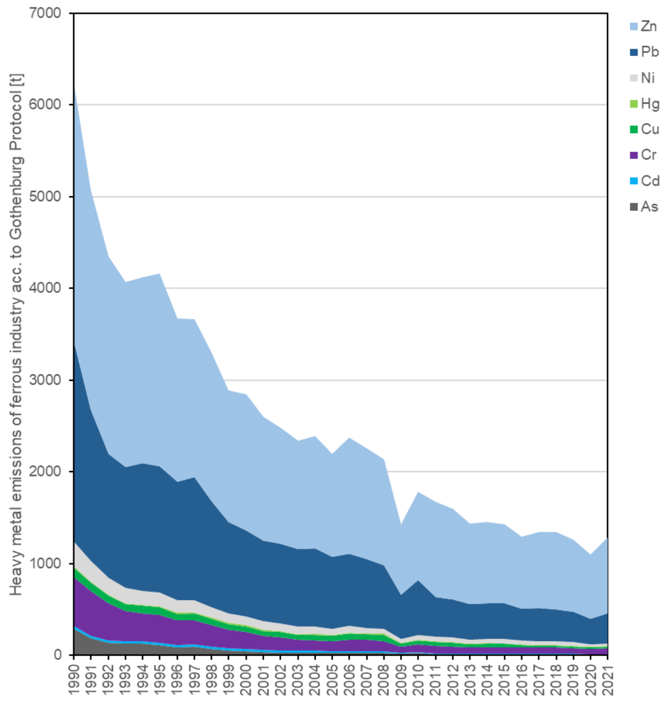

Figure 4: Dust emissions of selected elements from 1990

In 2023, the European Union released an emission inventory report covering the years 1990 – 2021 under the UNECE Convention on Long-range Transboundary Air Pollution (Air Convention). The report integrates data from the EU27 member states, Iceland, Liechtenstein, Norway, Switzerland, and Turkey (collectively referred to as EEA32). Our research concentrated on pollutant emissions from the EEA sector of raw material extraction and processing of iron and steel, with a focus on the heavy metals As, Cd, Cr, Cu, Hg, Ni, Pb and Zn (Figure 4). In the first years (1990 – 1997) of the analyzed data, there was a significant decrease in As, Cd, Cr, Ni and Pb. Thereafter, the annual decrease was lower but steady. Cu, Hg and Zn emissions tend to decrease steadily from 1990. The trend indicates a reduction in emissions, even if there was a slight increase in 2021.

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