PRODUCING CLEAN METAL FRACTIONS FROM DRY INCINERATOR BOTTOM ASH: WHAT IS THE ENVIRONMENTAL BENEFIT?

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A key element of a functioning circular economy (CE) is the efficient recycling of materials from post-consumer waste streams without contaminating recycling products. Studies have shown that bottom ash (IBA) from municipal solid waste incineration (MSWI) is a sink for considerable amounts of elements such as metals or mineral compounds (Chimenos et al. 1999; Jung et al. 2004). More recent studies have focussed on the resource potential of precious metals, platinum group metals as well as rare earth elements contained in the IBA (Allegrini et al. 2013; Morf et al. 2013; Muchova et al. 2009). From an environmental but also from an economic perspective, these elements are of particular interest, since their primary production is associated with large environmental impacts and costs (Nuss & Eckelman 2014). Therefore, attempts to efficiently recover metals from IBA as clean fractions have increased in the past few years (Boeni 2017; Born 2018). According to the CE strategy package by the EU adopted in 2018, recycled metals from MSWI residues can be credited to national recycling rates from 2020 on (European Commission 2018), which will further foster metal recycling efforts from IBA. A particular challenge of metal recycling is preventing quality losses through contamination i.e. producing high-quality metal fractions by accurate sorting (Daehn et al. 2017; Haupt et al. 2017). Also in Switzerland, optimising metal recycling from IBA has become a major part in urban mining strategies in the past few years. Maximizing both the recycling efficiency in general and the quality of each produced fraction in particular is the main goal of the mechanical IBA processing plant in Hinwil, Switzerland (Boeni 2017).

The aim of this study was to assess the ecological performance of the IBA processing plant in Hinwil, Switzerland, with focus on material qualities of the recycled metal fractions. Based on new mass-flow data, we perform a life cycle assessment (LCA). The analysis included the recovery of iron, aluminium, copper, lead, silver and gold. Fraction specific modelling allowed to consider product qualities as well as to investigate further future recycling potentials (denoted ‘residual metal potentials’) in the remaining IBA. The substitution potential of every fraction for primary metals was calculated considering the quality of the recovered metal. In addition to the recycling process and substitution potential, the implications of the new process on the landfill emissions of IBA residues were quantified. We considered landfill emissions within a time period of 1’000 years (base scenario), however, a short-term period of 100 years (ST scenario) as well as the worst-case scenario of a complete washout ($T=\infty$ scenario) are additionally assessed. The life cycle impact assessment (LCIA) included the impact categories of climate change, eco- and human toxicity as well as cumulative exergy demand of minerals extraction.

The results indicated large environmental savings due to primary metal substitution and reducing long-term emissions from landfills for every LCIA method. In the base scenario, metal product substitution contributes between 82 % and more than 99% to this saving, depending on the impact category. Reductions in landfill emissions were small in the short-term and base scenario, but became much more important when an indefinite time horizon was adopted. The fine IBA fractions (<12mm), which are set free by mechanical crushing, account for 28-54% of the net environmental benefit of recycling. In case of aluminium, the purity of the finest fraction (0.3-1.2mm) even enabled a direct recycling as powder without further processing steps, resulting in large relative credits despite the small absolute amount. The metal-based analysis illustrates the ecological relevance of recovering non-ferrous (NF) metals although their mass fraction is small. While copper represents only 4% of the recovered mass, its contribution to the net environmental credit is between 23% and 50% except for climate change. In case of gold, which represents less than 0.001% of the recovered mass, its recovery contributes between 1% and 26% to the net environmental benefit. The analysis of long-term landfill emissions showed that mainly copper recovery contributed to reduced environmental impacts. Finally, the analysis of residual metals revealed that there is a substantial potential of additionally recoverable metals in the remaining (and currently landfilled) IBA.

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