CRITICAL METAL EXTRACTION FROM MUNICIPAL SOLID WASTE INCINERATION ASHES AND THE IMPACT ON A CIRCULAR ECONOMY

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Introduction

Economic sectors such as construction, chemicals, automotive, aerospace, machinery and renewable energy correspond to more than 30 million jobs in the EU and depend on the sustainable supply of raw materials. In December 2015, the European Commission published a Circular Economy Package with the ambition to minimise waste, to keep resources in the economy for as long as possible and to increase energy and resource efficiency within the EU. A challenge to reach this goal is recovery of metals embedded in complex material. Some fractions are prone to always end up in municipal solid waste and landfilled. Sweden is in the forefront of using municipal solid waste (MSW) for energy supply. Nearly 50% of the produced waste is used for energy supply, *e.g.* district heating (88%) and electricity (12%). In addition, Sweden imports waste from Norway and United Kingdom to fulfill its energy need[1]. Waste incineration of municipal solid waste generates annually about 200 000 tons fly ash in Sweden[1]. The fly ash is usually classified as hazardous material due to the presence of potentially toxic metal compounds and easily soluble chlorides and has to be deposited into specialised landfills. As a consequence of landfilling, critical and valuable metals present in the fly ashes are lost and the waste contributes to a cost for the society. This proceeding explores the potential of taking advantage of the waste-to energy plants for recovering Zn and critical metals (CM) from MSW and the environmental and monetary impact compare to business as usual this entails.

Results and Discussions

Economic potential of Zn and critical elements locked in Swedish fly ash

Estimations based on the annual amount of Swedish waste fly ash give the potential value of Zn is about 7 million Euro, assuming a Zn metal price of 1.2 Euro/kg[2].

Consequently, there are large values that are not utilised. The amount of critical metals in fly ash from waste to Energy plants in Sweden 2012 is given in Figure 1.

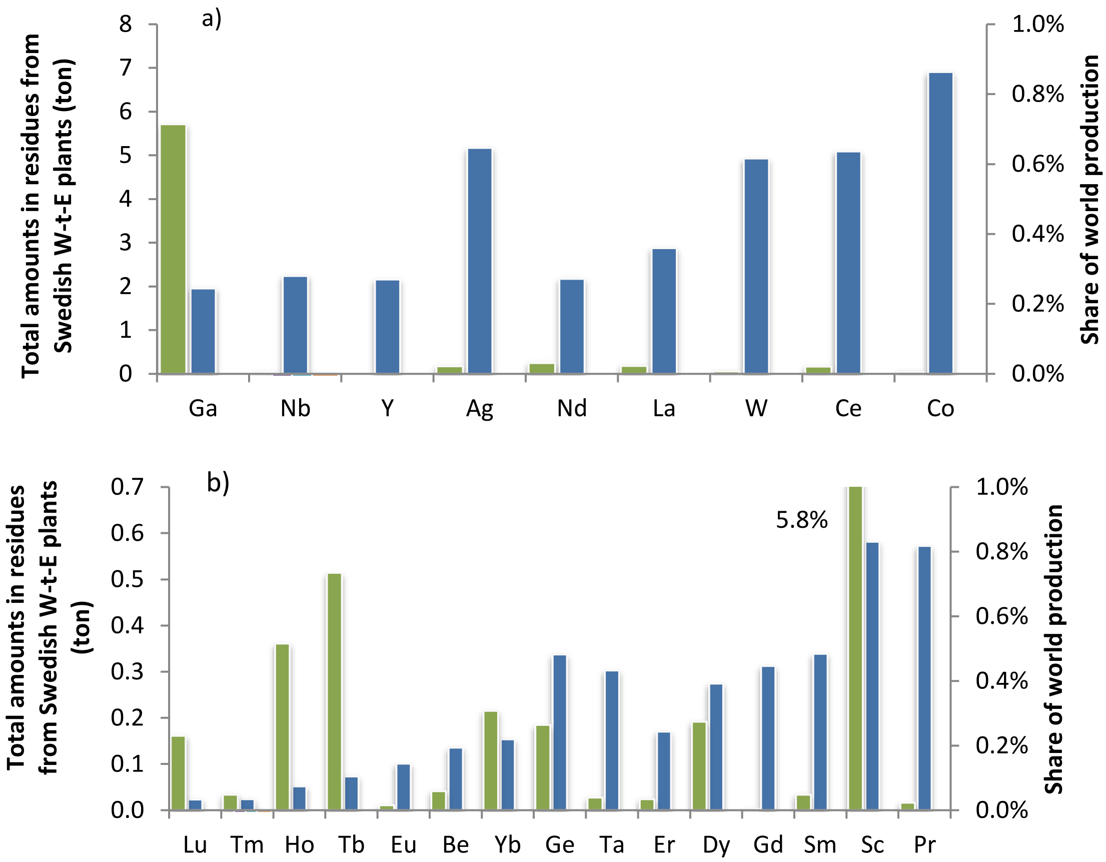

Figure 1: The amount of critical metals in residues from Swedish waste-to-energy plants in 2012. a) The total amount is above 1 ton/year and b) below 1 ton/year. Green bars indicate how large part of the world production the different amounts constitute

The results indicate the potential of fly ash from Sweden as a relevant source for some of the critical metals identified by the European Commission (Figure 1). The amounts constitute up to 5.8% of the world production (Figure 1). Although the respectively amounts in totals are high (Figure 1) the contents in the ash are generally lower than the contents in the average earth crust (results not shown). Exceptions are antimony, cobalt, silver, tantalum and wolfram with higher content in the fly ash than in the average earth crust. The value of the analysed critical metals in their pure form is about 140 Meuro/year (Figure 1; pricing MetalPrices.com; 2012). Lutetium, magnesium, scandium and thulium contribute to a large part of that potential. Magnesium is present in large amounts (11900 ton/year) while the others have a very high market price (in pure metallic form). Combined with Zn the value locked in fly ash is approximately 200 Meuro/year in Sweden only. Sampling and analysis of Zn and critical metals from 8 and 10 waste to energy plants respectively has been reported in technical reports[2,3].

The feasibility of recovering all these metals remains to be assessed. Magnesium recovery from fly ash is explored by Latrobe Magnesium (Australia) aiming at production of 5000 tons/day in 2016 with a 95% recovery rate at laboratory scale[4]. Zn recovery from fly ash has been demonstrated at commercial scale in Zuchwill, Switzerland with the capacity of producing 1 ton high-grade Zn/day with the so called FLUREC method[5]. Pilot scale tests treating 100 kg/h fly ash have also been performed in Sweden. 70% of the Zn could be leached using a one-step leaching procedure with a leaching. The recovered Zn was in the form of a filter cake containing 50-80% zinc hydroxide. The economic feasibility for this zinc hydroxide process depends on the Zn prices, the classification of the ashes and the landfilling costs. Preliminary results also show the technical feasibility of re-circulation of the ash residue to the incineration process with more than 90% of the re-circulated fly ash residue ending up in the bottom ash. Landfilling the residue is an alternative since it fulfilled the requirements for non-hazardous waste for all elements except for Sb. Further research on stabilisation of the ash residue is needed. The pilot scale tests have been reported in technical report by Andersson *et al.* 2016[6].

Environmental potential of mining Zn and Mg from fly ash

The process costs of metal recovery from fly ashes are high due to the relatively low contents and the fact that the metals are often present in complex chemical compounds, which makes the economics challenging. However, the benefits on the environment can be higher and there are therefore potential savings on the society cost. To illustrate this potential, a literature review on carbon and water footprint of primary mining of Zn and Mg were performed (Figure 2.)

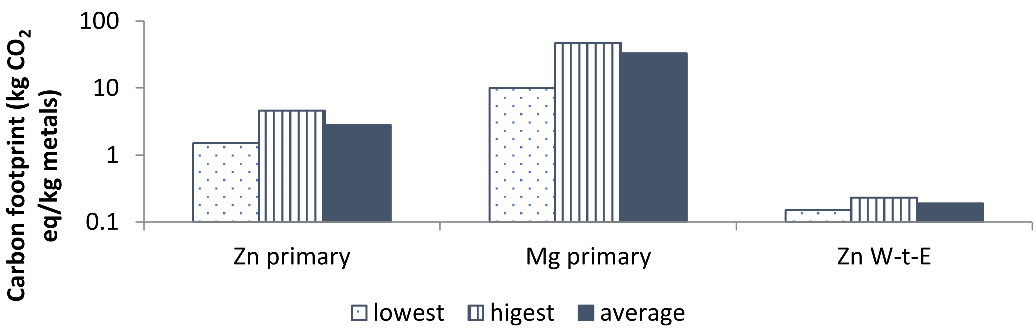

Figure 2: Carbon footprint of Zn[7] and Mg[8] from primary sources based on literature and of Zn production from fly ash from Waste-to-Energy plants in Sweden (0.23 kg CO_2 eq/kg Zn; estimated values) and with the FLUREC process in Switzerland[9]

The data shows that primary mining has significant negative impact on the green-house gas emissions and water although the data can vary a lot between plants (Figure 2). If the metals life span in the economy can be prolonged with recycling in Waste-to-Energy plants, the greenhouse gas emissions can be reduced 7-20 folds (Figure 2). Water footprint can also be significantly reduced from primary mining, which reach 370 L water/kg Zn[10] and 10-47 L water/kg Mg[8] for primary mining, since

the proposed Swedish process is closed. Inlet water is waste water from incineration and can technically be upgraded to high standard after the process and recirculated to a large extent. Obvious benefits are also to be found in waste reduction and reduced land use change and acidification but these are not quantified in this report.

Conclusions

By recovering the metals from fly ash, the life-time of the metals can be increased even from difficult material matrixes. The Swedish pilot example indicates that it is technically and economically feasible to extract Zn from fly ash depending on *e.g.* the metal prices. Landfilling of fly ash is not a sustainable solution and with higher demands for metals it will be an even worse treatment alternative in the future. Valuable metals needed for the European economy are being lost, which in turn translates into a cost to society. Compensating this lost with primary mining results in high water and green-house gas emissions that further contribute to this cost.

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