Resource recovery in MSWI fly ash treatment: technological aspects and environmental perspective

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Introduction

Fly ash and/or air pollution control residues (abbreviated as FA) are the solid residues produced in municipal solid waste incineration (MSWI) plants. The total production of FA in Europe is estimated at about 3-5 million tonnes per year. FA is a hazardous waste due to its high content of potentially toxic elements, soluble salts, and organic pollutants, but the quantity produced and the content of valuable components make this material a suitable secondary source for recovery (Quina et al., 2018; Zhang et al., 2021).

The recovery of materials from FA is possible by hydrometallurgical methods, where the most promising full-scale processes are FLUWA/FLUREC (acid extraction) and HALOSEP (water washing combined with acid extraction). The FLUWA technology is operated at the TERMIZO MSWI plant in the Czech Republic. The main goal of the FLUWA was to remove hazardous properties from FA. Metals were not recovered. Instead of this, metals were transferred into insoluble filter cake and landfilled as hazardous waste.

The aim of our work was to propose an optimised procedure for the removal of hazardous properties of FA and the recovery of valuable components from it. This paper summarizes the results of semi-pilot and pilot scale testing of individual steps of optimized FA treatment in the MSWI plant TERMIZO.

Materials and methods

A detailed characterisation of all input and output technological streams was performed. The chemical composition and properties of the solid and liquid technological streams were analysed. The elemental composition of solid materials (fly ash, gypsum, filter cake) was determined by aqua regia acid digestion followed by ICP-OES analysis (Perkin Elmer). Leachability tests and ecotoxicological tests were performed to evaluate the environmental properties of the solids. Leachability tests were performed according to EN12457-4. Acute toxicity tests were performed with *Daphnia magna* according to ISO 6341 and algal growth inhibition tests were performed with *Desmodesmus subspicatus* according to ISO 8692. Elemental composition (ICP-OES, Perkin Elmer) and anion content (electrophoresis, Agilent 7100) were measured in liquid materials (process water, extract, effluent) and leachates. A material flow analysis of the FA treatment before and after optimisation was carried out. The technological and environmental impacts of the optimised FA treatment were evaluated.

Results and discussion

Selected results of the ecotoxicological evaluation of the FA before and after treatment are shown in Figure 1, the composition of the leachates from the FA before and after treatment is shown in Table 1, the composition of the metal-rich filter cake before and after optimisation of the FA treatment is shown in Table 2.

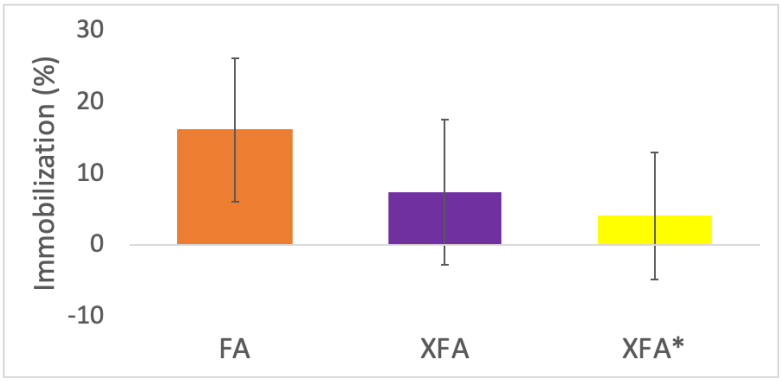

Figure 1. Immobilization of *Daphnia magna* after 48 hours: FA – raw fly ash, XFA – fly ash after acid leaching, XFA* - treated fly ash after additional washing

Table 1. Content of selected elements in leachates and legal limits for non-hazardous waste

Parameter	Content (mg/l)			Legal limits (mg/l)
	FA	XFA	XFA*	
Total dissolved solids (TDS)	26,000	7,900	4,000	8,000
Sulphates (SO_4^{2-})	5,170	1,470	1,500	3,000
Cadmium (Cd)	6.00	0.470	0.030	0.500
Lead (Pb)	<3.00	<0.120	<0.050	5.00
Selenium (Se)	<3.00	<0.100	<0.040	0.700
Zinc (Zn)	4.00	2.10	0.100	20.0

The results show that the optimised FA treatment significantly improves the environmental properties of FA. Leachates from treated FA meet the legal limits for non-hazardous waste. Treated FA also shows lower immobilisation of *Daphnia magna* compared to raw FA. In all cases, the immobilisation of *Daphnia magna* meets the legal limits (less than 30% after 48 hours).

Table 2. Average composition of Zn-content filter cake

Element	Content (% DM)	
	before optimization	after optimization
Zn	5–13	40–45
Ca	15–25	<0.5
Fe	0.8–1.5	<0.1
K	0.5–1.5	<0.1
Na	2.0–3.0	1.0–1.5
Al	<1.0	<0.1

The results show that the proposed FA treatment significantly improved the composition and properties of the produced filter cake. The chemical composition and parameters of the filter cake after optimisation of the FA treatment meet the technological requirements and can therefore be used in smelters as a secondary source of Zn.

Conclusions and perspectives

This paper summarises the results of semi-pilot and pilot scale testing of individual steps of the optimised FA treatment in the MSWI plant TERMIZO. The proposed process has several technological and environmental advantages. Firstly, the optimised FA treatment efficiently removes hazardous properties of FA and significantly improves its environmental properties. Secondly, the process improves the quality of the produced outputs, allowing the recovery of Zn, gypsum, salts and water. Thirdly, the process significantly reduces the consumption of process chemicals and almost completely eliminates the production of hazardous waste. Finally, it applies circular economy principles and moves MSWI towards zero waste technology. The proposed FA treatment will be presented and discussed in detail. The results of the feasibility study will also be presented.

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References

Quina, M. J., Bontempi, E., Bogush, A., Schlumberger, S., Weibel, G., Braga, R., Funari, V., Hyks, J., Rasmussen, E., & Lederer, J. (2018). Technologies for the management of MSW incineration ashes from gas cleaning: New perspectives on recovery of secondary raw materials and circular economy. In *Science of the Total Environment* (Vol. 635). https://doi.org/10.1016/j.scitotenv.2018.04.150

Zhang, Y., Wang, L., Chen, L., Ma, B., Zhang, Y., Ni, W., & Tsang, D. C. W. (2021). Treatment of municipal solid waste incineration fly ash: State-of-the-art technologies and future perspectives. *Journal of Hazardous Materials*, *411*, 125132. https://doi.org/https://doi.org/10.1016/j.jhazmat.2021.125132