# Carbonation for fixation of metals in MSWI fly ash

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## Introduction

Waste management is in need of a reliable and economical treatment method for metals in fly ashes from municipal solid waste incineration (MSWI). However, no state-of-the-art technique has gained wide acceptance yet. This work aims to assess the impact of carbonation on the mineral formation as well as its possibilities and limitations as a stabilization method.

## Research questions

- What are the critical metals requiring treatment of MSWI fly ash?
- How is the availability of these metals affected by carbonation?
- What are the possibilities and limitations of this method with a view to technical applications?

## Experimental

MSWI fly ash from a Swedish mass burning unit was characterized and carbonated. Carbonation variables that were studied are the partial pressure of carbon dioxide ($CO_2$), the addition of water, the temperature, and the reaction time. Laboratory experiments were performed applying methods such as factorial experimental design, thermal analysis, scanning electron microscopy (SEM), x-ray diffraction (XRD), and leaching assays including $pH_{stat}$ titration and sequential extraction. Leaching data were verified and complemented using chemical equilibrium calculations. Data evaluation was performed by means of multivariate statistics such as multiple linear regression, principal component analysis (PCA), and partial least squares (PLS) modeling.

## Conclusions

It was found that carbonation is a good prospect for a stabilization technique especially with respect to the major pollutants Pb and Zn. Their mobility decreased with increasing factor levels. Dominating factors were the partial pressure of $CO_2$ and the reaction time, while temperature and the addition of water were of minor influence. However, the treatment caused a mobilization of Cd, requiring further research on possible countermeasures such as metal demobilization through enhanced silicate formation.

Silicate formation and subsequent clay formation were identified as potentially additional sequestration processes for metals

The rate of decalcification is one decisive factor that determines the long-term stability and denudation of carbonated MSWI fly ash. For a typical landfill in Sweden, the

decalcification of completely carbonated fly ash was estimated at 0.13 mm $yr^{-1}$ (figure 1). If the partial pressure of $CO_2$ is higher than atmospheric conditions, the decalcification rate of fly ash increases. Co-disposal of pretreated MSWI fly ash with putrescibles might lead to a decalcification that can be very difficult to predict and, thus, control because of the variable generation and distribution of $CO_2$. However, the impact of the processes needs to be estimated and quantified also experimentally, in particular, with respect to the release of metals.

Carbonation of fly ash reduces the potential for precipitation in and clogging of leachate collection pipes.

A reasonable and practical source of $CO_2$ is needed before carbonation is applied at full-scale. Landfill gas might be a possible option, but it is not always available. $CO_2$-rich flue gas is generated at all incinerators, but seems to be inappropriate due to the remaining oxidation capacity, which increases the risk of mobilizing Cr. However, the redox reactions that very likely control the mobility of Cr in MSWI fly ash are not well understood. Speciation experiments in combination with equilibrium calculations could fill this gap.

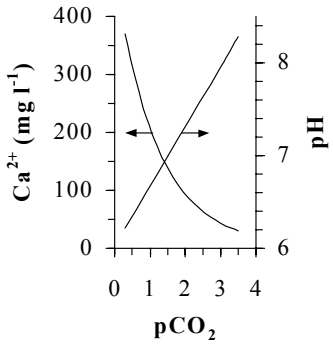


***Figure 1*** *$Ca^{2+}$ concentration and pH in landfill leachate from carbonated fly ash as a function of the negative logarithmic partial pressure of $CO_2$ ($pCO_2$) (Ecke et al. in print b). The underlying chemical equilibrium calculations take into account (1) the chemical composition of the local precipitation (Rickleå near Umeå, Sweden), (2) redox equilibrium of the rain-water with atmospheric $O_2$, (3) 33% evapotranspiration with the respective increase in component concentration, and (4) an in-situ temperature of 5°C.*

## References

Ecke, H., Bergman, A. & Lagerkvist, A. (1998) Multivariate data analysis (MVDA) in landfill research. *The Journal of Solid Waste Technology and Management* **25**:1, 33-9.

Ecke, H., Menad, N. & Lagerkvist, A. (in print a) Carbonation of MSWI fly ash and the impact on metal mobility. *Journal of Environmental Engineering*.

Ecke, H., Menad, N. & Lagerkvist, A. (in print b) Treatment-oriented characterization of metal-bearing dry scrubber residue from municipal solid waste incineration (MSWI). *Journal of Material Cycles and Waste Management* **4**:2.

Ecke, H., Sakanakura, H., Matsuto, T., Tanaka, N. & Lagerkvist, A. (2000) State-of-the-art treatment processes for municipal solid waste incineration (MSWI) residues in Japan. *Waste Management & Research* **18** 41-51.

Ecke, H., Sakanakura, H., Matsuto, T., Tanaka, N. & Lagerkvist, A. (2001) The effect of electric arc vitrification of bottom ash on the mobility and fate of metals. *Environmental Science & Technology* **35**:7, 1531-6.