LCM 2025

12th INTERNATIONAL CONFERENCE ON LIFE CYCLE MANAGEMENT

Accelerated carbonation of Municipal Solid Waste Incineration Bottom Ash (MSWI-BA) for sustainable low-cement concrete: a Life Cycle Assessment approach

de la Reta Pablo[1], Kanjo Imad Eddine[1], Courard Luc[1], Marquis Séverine[2], Léonard Angélique[1]

(1) University of Liège ; (2) Centre de Terre et Pierre

http://www.chemeng.ulg.be ; pdelareta@uliege.be – a.leonard@uliege.be

Introduction

Municipal solid waste incineration bottom ash (MSWI-BA), a residual material from waste incineration, is typically used in construction after an 18-week maturation period. This study explores an innovative accelerated carbonation process to transform MSWI-BA into low-cement concrete, aligning with circular economy goals and reducing environmental footprints.

Guided by eco-design principles and Life Cycle Assessment (LCA), the research evaluates the environmental performance of carbonated concrete blocks with a 30-year service life and 40 MPa compressive strength.

The CARBOC project

Ipalle, an intercommunal waste-to-energy plant incinerating 400 000 tons of waste annually and 2 Walloon construction firms TRBA and Roosens, which are 2 big raw material consumers, are actively seeking to reduce their carbon footprint and advance circular economy practices. A key strategy involves developing alternative concrete formulations by substituting raw materials with industrial byproducts and reducing hydraulic binder content (a major CO_2 source and less cement consumption).

Figure 1: Municipal Solid waste incineration bottom ash (MSWI-BA)

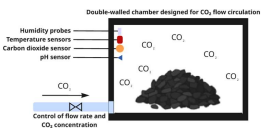


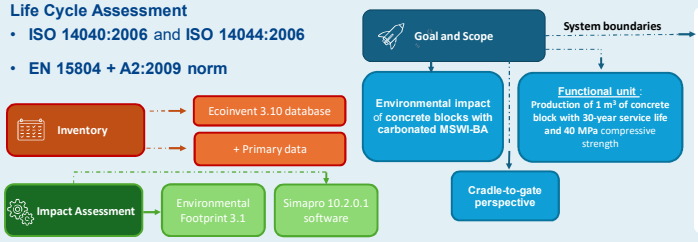
Figure 2: Carbonation of MSWI-BA

Figure 3 :Concrete blocks made with carbonated MSWI-BA

Methodology

Life Cycle Assessment

- **ISO 14040:2006** and **ISO 14044:2006**
- **EN 15804 + A2:2009 norm**



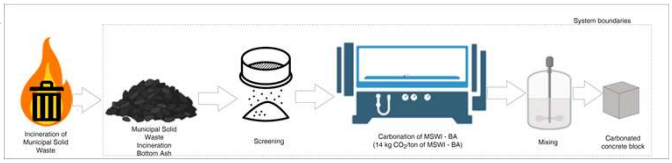


Figure 4: System boundaries for the production of 1 m³ of a concrete block with carbonated MSWI-BA

Results

LCA revealed the carbonated MSWI-BA concrete block outperforms standard blocks in most environmental indicators (except ionizing radiation). Figures 6 - 7 detail production hotspots and normalized impacts

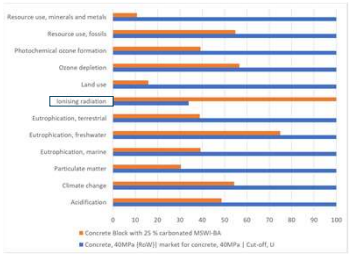
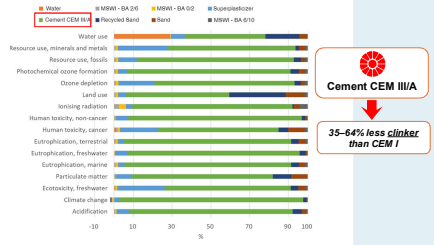


Figure 5: Comparison between the production of 1 m³ of standard concrete block and 1 m³ of concrete block containing 25% carbonated MSWI-BA. Method used: EF 3.1



Cement CEM III/A

35–64% less clinker than CEM I

Figure 6: Characterization of 1 UF. Method used: EF 3.1

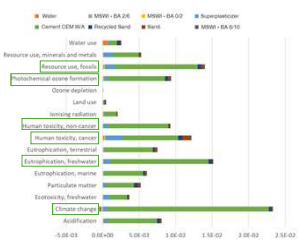


Figure 7: Normalization of 1 UF. Method used: EF 3.1

Conclusion

Insights

This study conducted an LCA following EN 15804 + A2:2019 standard to evaluate the environmental impacts of producing 1 m³ of concrete containing 25 % of carbonated MSWI-BA.

The **cement CEM III/A production** ➔ main contributor to : **climate change, eutrophication (freshwater), resource use (fossils), human toxicity (cancer and non-cancer)** and **photochemical ozone formation** Carbonated MIOM showed a slightly positive effect on **climate change** (14 kg of CO_2/ton of MSWI-BA).

Outlooks

- *Increase carbonated MSWI-BA content in concrete formulations.*
- *Optimize CO_2 absorption during carbonation.*
- *Explore post-production carbonation of concrete blocks using the new carbonation chamber (pilot scale).*

Funded by the Walloon Region as well as by GreenWin, this project integrates the REMIND (Reverse Mineral Industry in Wallonia) initiative. REMIND is an industrial, technological, and scientific platform advancing mineral material circularity.