Valorization of biomass ashes as eco-friendly supplementary cementitious materials

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GENERAL OVERVIEW OF THE PROJECT

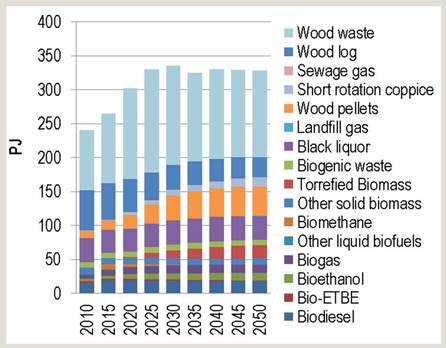
This study explores the use of biomass ashes from local and European sources as supplementary cementitious materials (SCMs). Mechanical-chemical activation, water washing, and accelerated carbonation were applied to improve ash properties. Treated ashes were characterized and used in cementitious mixtures to assess performance. Early results indicated improved reactivity and stability. A Life Cycle Assessment will evaluate the environmental impacts. The findings aim to promote the sustainable use of biomass ashes in the construction sector through effective valorization strategies.

1. INTRODUCTION

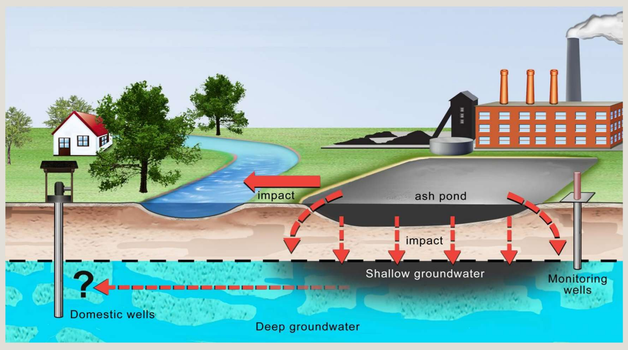
Biomass ash, while not categorized as hazardous waste, is becoming increasingly abundant due to the growing number of biomass power plants.

Its utilization as a SCM offers a dual benefit: mitigating environmental concerns associated with ash disposal and supporting circular economy practices.

However, the mineralogical composition and chemical characteristics of ash vary significantly depending on its source. Therefore, appropriate pre-treatment processes are required before its incorporation into cementitious systems.



2. STUDY OBJECTIVES



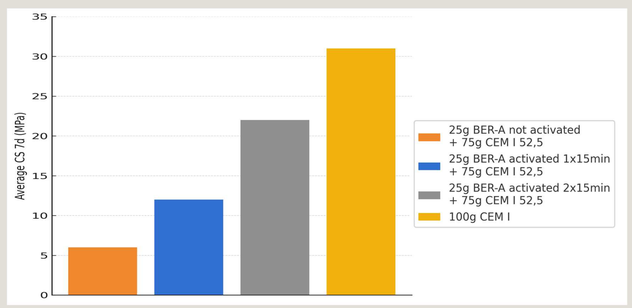
This study investigates the suitability of biomass ashes—sourced from both local and various European regions—for use as a partial replacement for cement in cementitious systems. The primary aim is to identify which pre-treatment methods are most effective in enhancing the performance of these ashes for such applications.

Providing a better understanding of the effects, outcomes, and costs of different treatments will support the integration of recycled biomass ashes into the building sector as sustainable SCMs.

3. METHODOLOGY

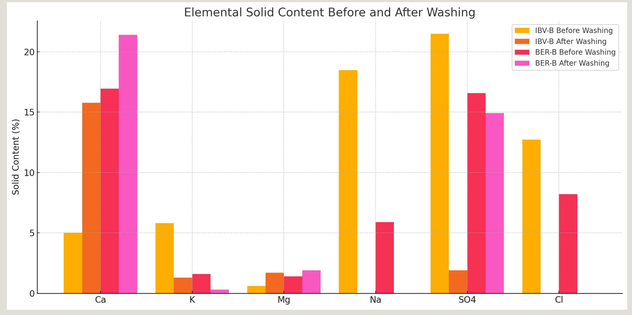
- Biomass ash samples were collected from local and European sources.
- Physical and chemical characterization was performed.
- Based on these results, different pre-treatment methods were applied.
- Treated ashes were re-characterized to assess changes.
- Ashes were used to partially replace Portland cement in mortar mixtures.
- The mixtures were tested for strength, setting time, and workability according to standards.
- A Life Cycle Assessment will be conducted to evaluate the environmental impacts of selected treatments.

4. EFFECTS



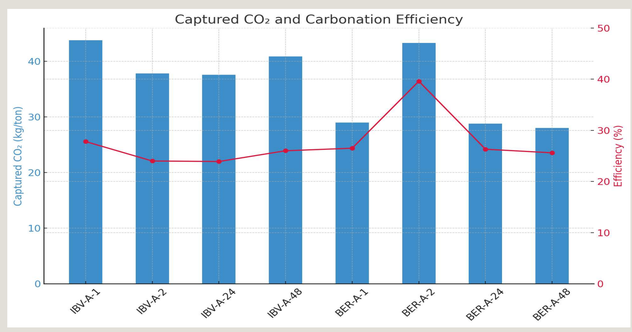
Mechanochemical-Activation (MCA)

MCA is a high-energy grinding process that reduces particle size and increases surface area. It amorphizes quartz and releases reactive silica, which enhances the reactivity and the substitution potential of the ash. It may contribute to the stabilization of heavy metals.



Water-Washing (WW)

WW is a simple but effective method used to remove soluble salts, alkalis, and loosely bound impurities. This process improves the chemical stability of the ash, reduces potential durability issues in cementitious systems, and helps prevent undesirable reactions such as ASR.



Accelerated Carbonation (AC)

AC involves exposing biomass ash to controlled CO_2 environments to promote the formation of stable carbonates. This treatment enhances the chemical stability of the ash, reduces its pH, immobilizes heavy metals and can improve the compatibility of ash by modifying its surface chemistry.

5. CONCLUSIONS

- Biomass ashes have diverse chemical and mineralogical compositions.
- Each ash requires specific characterization and tailored treatment.
- Water-washing effectively removes soluble salts but involves high costs.
- Accelerated carbonation may reduce compressive strength; combining it with MCA can help overcome this.
- MCA significantly enhances ash reactivity and shows the highest potential for cement replacement.

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