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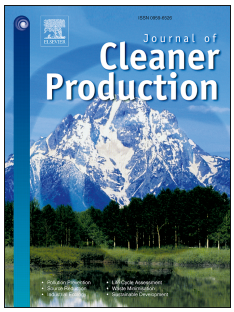

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Is Open-Loop Recycling the Lowest Preference in a Circular Economy? Answering Through LCA of Glass Powder in Concrete

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Abstract

The government of Quebec (Canada) is trying to find a useful outlet for the mixed waste glass pilling up in its landfills. One solution to consider is the use of fine glass powder from mixed waste glass as alternative cementitious materials (ACM) in concrete, using an open-loop circular-economy principle.

To quantify the environmental feasibility of this concept, life cycle assessment (LCA) methodology, in combination with a real case study (i.e., a concrete sidewalk in Montreal, Canada) are both assessed. More specifically, two different scenarios are compared, the business-as-usual (BAU) concrete production model, and a glass powder (GP) concrete production process model. All modeling efforts are performed using SimaPro 8.2 software, the Ecoinvent 3.2 database and the IMPACT 2002+ impact method. Finally, a Monte Carlo simulation, in addition to different sensitivity analyses, are carried out to assess the influence of data uncertainty and key parameter changes, such as the distance from suppliers, potential lifetime extension of the concrete, and possible particulate emissions during GP production.

Results show the environmental benefits of using GP as an ACM in terms of every indicator. Moreover, the significant contribution of cement production in the environmental burden of concrete is noted. It appears as the main hotspot in most midpoint indicators, and in all four endpoint indicators. It is especially highlighted as a global warming indicator, with 74% of the greenhouse gasses (GHG) related to cement production for the BAU scenario and 68% for the GP scenario. The emissions of particles into the atmosphere (such as CO_2, NOx, and SOx) from the clinker kiln chimney plays a major role in the overall environmental impact of concrete production. Another key result is the importance of transportation distance of the base materials, which could reverse the conclusion.

The originality of this paper relies on the environmental assessment of the up-cycling of GP as a supplementary cementitious materials (SCM) in concrete. Indeed, this study allows for a better understanding of environmental impact of concrete and highlights the extent to which environmental benefits remain when mixed waste glass is used in an open-loop circular-economy context. At a larger scale, this study aims to encourage all municipalities/government that are struggling with common waste – such as mixed waste glass -- to find industrial symbioses at a local scale.