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Ecological assessment of the use of hydrochar in EAF operation based on an LCA approach

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Electric arc furnaces (EAFs) rely on carbonaceous materials (e.g., anthracite, coke breeze, or synthetic graphite) for slag foaming, oxygen refining, and energy efficiency. Replacing fossil-derived carbon with hydrochar, produced via hydrothermal carbonization (HTC) of biogenic residues, could lower the environmental footprint of steelmaking. Yet the net benefit depends strongly on feedstock origin, process energy, and operational substitution rates. This study presents an ecological assessment of hydrochar use in EAF operation based on a life cycle assessment (LCA) framework.

The goal is to quantify potential environmental impacts and identify key drivers and trade-offs when hydrochar substitutes conventional fossil carbon in EAF practice. The LCA follows ISO 14040/14044 principles, applying a functional unit of "1 tonne of liquid steel produced in an EAF"and comparing a baseline fossil-carbon scenario with multiple hydrochar integration scenarios. Impact categories include climate change, particulate matter formation, acidification, eutrophication, resource use, and water-related indicators.

Results indicate that hydrochar can meaningfully reduce fossil carbon demand and associated greenhouse gas emissions, particularly when produced from residue streams with low upstream burdens and when HTC/drying energy is supplied by low-carbon sources or recovered heat. However, benefits may be offset by higher processing energy, increased ash handling, and potential trade-offs in acidification/eutrophication depending on feedstock cultivation and nutrient emissions. Hotspots typically include energy for dewatering/drying and the electricity mix, making decarbonized energy supply and process integration critical. The study provides guidance on environmentally robust hydrochar supply chains and operational conditions under which hydrochar contributes to lower-impact EAF steelmaking.

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