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Environmental Impact of Rare Earth Elements in Permanent Magnets of Electric Machines for Industrial and Automotive Applications: a Systematic Review

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Objectives

This study aims to conduct a systematic literature review of the environmental impact of industrial applications using Rare Earth Elements (REEs) classified as Critical Raw Materials (CRMs) such as Neodymium alloys. These materials are essential components of permanent magnets used in Electrical Machines (EMs), e.g., automotive applications, wind turbine generators, and various consumer electric and electronic products. The study aims to assess the current state of scientific knowledge on the environmental challenges of these components during their life cycle, from extraction to end-of-life (EoL) management, which is a fundamental phase according to the European strategy on CRM. Such data are functional to improve the design of systems in the direction of environmental-conscious approach.

Methods

This systematic review follows a structured methodology, beginning with a comprehensive search on multiple databases using a combination of primary and secondary keywords. The selection process involves several steps, including selection by title, abstract, and full-text evaluation to ensure inclusion of relevant studies. The review follows established guidelines for systematic literature reviews to maintain reproducibility of the study.

Results

The literature review provides an overview of the current scientific literature on the environmental impact of rare earth elements in permanent magnets. It identifies key results, research gaps, and the strengths and limitations of existing studies. This review also highlights emerging trends and potential areas for future research.

Conclusions

In the context of Ecodesign, Circular Economy principles, and the growing importance of Digital Product Passport (DPP) for Critical Materials, this literature review highlights the need for other research to fill knowledge gaps. This work provides information on the environmental consequences of the use of rare earth elements and highlights areas that require attention to support the development of more sustainable and efficient materials management strategies.

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