

Title: Unlocking Barriers to Innovation: A Sociotechnical Perspective on the Deployment of MgO-Based Reagents in Mine Water Treatment

Despite the clear economic and environmental benefits of innovative water treatment technologies, adoption within the mining sector—especially in mine wastewater management—has been notably slow. This resistance persists despite decades of research and policies aimed at accelerating innovation. Traditional strategies for fostering technology deployment, including policies focused on Technology Readiness Levels (TRLs), tech-to-market programs, matchmaking initiatives, and grants, have led primarily to incremental improvements. However, these methods have seen limited success in achieving the transformative changes required to meet essential sectoral objectives like energy efficiency, risk reduction, and sustainable water stewardship. The challenge lies in facilitating the adoption of breakthrough innovations, yet existing frameworks have not adequately addressed specific adoption barriers that prevent these advancements from reaching their full potential.

This paper adopts an alternative analytical approach to investigate the complex web of factors influencing technology adoption in the mine wastewater sector. Moving beyond solely technological factors and traditional push strategies, we apply a sociotechnical systems perspective to examine the multifaceted challenges innovations face from introduction to potential stabilization. This framework considers the interdependencies between social, technical, cultural, and institutional dimensions, shedding light on how innovations encounter resistance or support across various intertwined regimes. By examining the introduction of an MgO-based reagent as a niche innovation in mine wastewater treatment, we explore how policy, market structures, technical norms, and scientific standards collectively shape technology acceptance and diffusion processes.

Our case study reveals that while the MgO-based reagent offers compelling advantages in enhancing water quality and reducing environmental impacts, scaling beyond niche applications remains constrained by structural barriers. These barriers include policy and regulatory frameworks that favor established practices, market dynamics that limit competitive entry, and scientific validation processes that impose higher burdens on novel approaches. These factors illustrate how regimes work to stabilize existing technological systems, often at the expense of accommodating potentially transformative alternatives. The sociotechnical approach thus highlights the roles of social and organizational networks, vested interests, and path dependencies that conventional technology adoption frameworks may overlook.

In conclusion, our findings suggest that adopting a sociotechnical systems perspective in analyzing and promoting innovations in the mine wastewater sector offers valuable

insights for both policymakers and technology managers in mining corporations. By understanding the complex dynamics that hinder technology scaling, stakeholders can more effectively identify and address non-technical barriers, fostering an environment conducive to breakthrough advancements. This perspective encourages a shift from focusing solely on TRL levels and incremental, grants-based policies to more integrative strategies that account for interconnected socio-technical factors. Such a holistic approach is essential for realizing the full environmental and economic potential of innovative solutions in mine wastewater treatment, advancing the sector toward meaningful sustainable practices and responsible water stewardship.