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Sustainable purification technology for mining and metal industry water flows – Green chemical treatment system using steel industry slag byproducts

State-of-the-Art

Project P2025-03619

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Project Puremine and our consortium

The project will systematically evaluate the effectiveness of slag granules in purifying mine water and industrial stormwater under real field conditions. It will characterize the mineralogy of spent slag granules and identify the mechanisms responsible for metal removal, aiming at further improving material performance. Finally, PUREMINE will investigate the use of electrodialysis (ED) to recover valuable metals from metal-saturated slag granules.

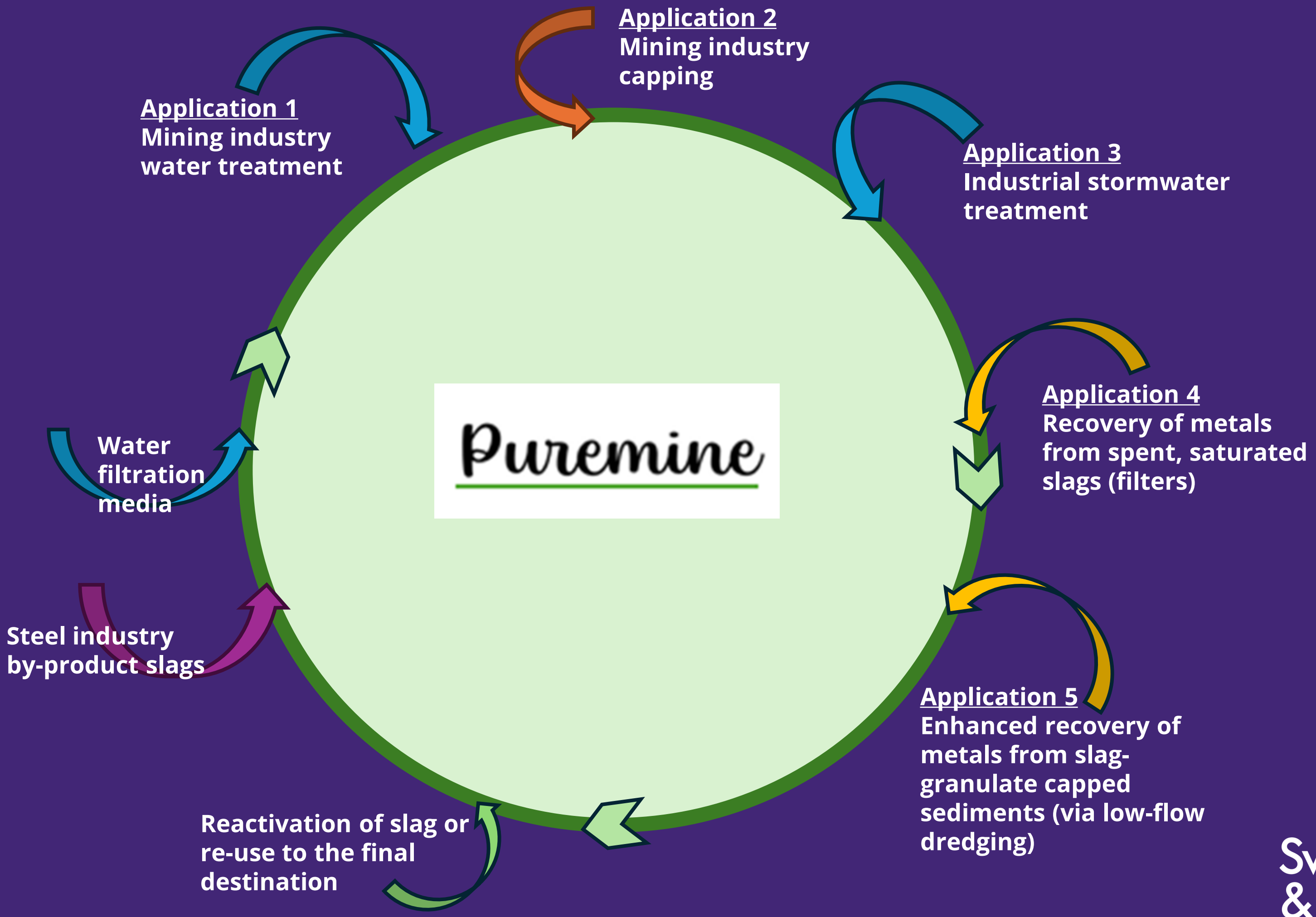
The PUREMINE initiative uses steel slag as a value-added green by-product for the removal of metals and other contaminants. The Höganäs Sweden AB granulated product Petrit T-S and Avesta Outokumpu AOD-slag have shown promising filtration and sorption capacities.

KTH VETENSKAP OCH KONST | LULEÅ TEKNISKA UNIVERSITET | LUNDS UNIVERSITET | BOTNIA GOLD | Höganäs | outokumpu high performance stainless steel | Techmarket Sweden AB

Concept – the PUREMINE circularity

Circular Economy Approach

- Design out waste and pollution
- Keep products and materials in use
- Regenerate natural systems



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Pilot/full-scale implementation

Mine: L. Fäbotjärn, Vindelgransele

Steel industry: Höganäs Halmstadsverken

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Literature review

- 1,542 research articles (2001–2020) on mining wastewater treatment (Review by Zahoor et al. 2022)
- Treatment technologies and resource recovery techniques review; four commercialised systems reported (Review by Matebese et al. 2024)
- Extensive literature on general stormwater treatment solutions, but significantly fewer studies address stormwater from specific industrial areas

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Active and passive methods for mine and industrial wastewater treatment

Chemical treatment/metal precipitation

PCCell
Electrodialysis Unit
(Lund University)

Currently available technologies/methods

Active methods	Passive methods
Electrochemical processes: electrowinning, electrocoagulation, electrodialysis/membrane-based electrodialysis	Limestone drains (anoxic or oxic)
Membrane-based processes: ultrafiltration, nanofiltration, reverse osmosis, forward osmosis	Constructed wetlands (vertical or horizontal)
Precipitation methods	Sulfate-reducing bioreactor
Bioreactors	Settling ponds
Ion exchange	Permeable reactive walls (groundwater)
Sorption	Vertical flow reactor with reactive filter media
Advanced oxidation	Passive oxidation systems
Flotation liquid-liquid extraction	

*Technologies marked in green are used in PUREMINE

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Industrial challenges

- Water technology (treatment tech the majority) patenting has grown fourfold since the early 1990s.
- Most patents filed by universities and research institutions are never licensed or are licensed but never scaled.
- The European Patent Office notes that academia plays a major role in early-stage innovation.
- Commercialization is dominated by large firms (e.g. Veolia, Xylem, Kurita, etc.).

A barrier in a Swedish and international context is that academic innovations often stall before commercialization because;

1) They are proven only at laboratory or pilot scale and lack long-term performance data,
2) Industrial buyers are risk-averse and prefer established technologies, and
3) Scaling from TRL 4-6 to TRL 8-9 requires capital that research groups rarely have.

Filter material producer	→	Filter system	→	Management	→	Filter material recycling
Slag byproduct e.g. Petrit T-S		Constructed on-site or prefabricated		System user, e.g. mining company		Recycling company

The PUREMINE case

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Conclusion

- It may take time before treatment technology solutions are considered proven, and for industrial partners and researchers to validate their long-term performance.

- It is essential to conduct pilot trials in the field under the natural and climatic conditions prevailing in Sweden to validate a water treatment solution.

- The research prospects in the field of water purification highlight the urgent need for coordinated and sustained efforts that must be made quickly to create the conditions for the future of the Swedish mining and steel industry in harmony with the economic and environmental requirements that are being set.

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