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for sustainable water technology

Opening the black box of sludge dewatering

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Motivation

Sewage sludge is a significant byproduct of wastewater treatment plants, and its amount is steadily increasing. Over the past decade in Europe, the annual production of sewage sludge is approximately 9 million tons of dry mass (DM)[1]. Of the sludge treatment processes, dewatering is an essential step for sludge minimization, transportation, and management; however, the current process has various challenges and is expensive[2]. Furthermore, the complex structure of sludge makes dewatering even more complicated.
Improving the understanding of sludge dewaterability requires linking fundamental sludge characteristics with full-scale performance. Despite extensive research, predictive models remain limited in their applicability due to the highly variable composition of sludge originating from different treatment plants and operational conditions. Developing a systematic approach that integrates sludge physicochemical properties, microbial community structure, and advanced data-driven analysis could provide new insights into the mechanisms governing water release. Such knowledge is crucial for designing more robust and cost-effective dewatering strategies, ultimately reducing energy demand and enabling sustainable sludge management.

Technological challenge

The main technological challenge in sludge dewatering lies in the highly heterogeneous nature of sewage sludge, which combines inorganic particles, extracellular polymeric substances (EPS), microbial cells, and bound water[3]. This complexity leads to poor predictability of dewatering behavior and limits the efficiency of conventional methods such as centrifugation, filtration, or conditioning with polymers[4]. There is a need for the identification of various sludge parameters that influence dewatering.

Also, there is a mismatch between lab-scale dewatering indices and full-scale performance. Currently, the commonly used dewatering indices include Capillary Suction Time (CST) and Specific Resistance Time (SRF). However, they often do not correlate with the full-scale performance, creating a gap between laboratory-scale findings and full-scale application. Recent studies, including STOWA (2024)[5] demonstrate that the Modified Higgins Centrifuge Test can yield dewatering parameters that reasonably represent the full-scale performance. Nevertheless, standardisation of the method and its operating conditions is required to ensure reproducibility and consistent interpretation.

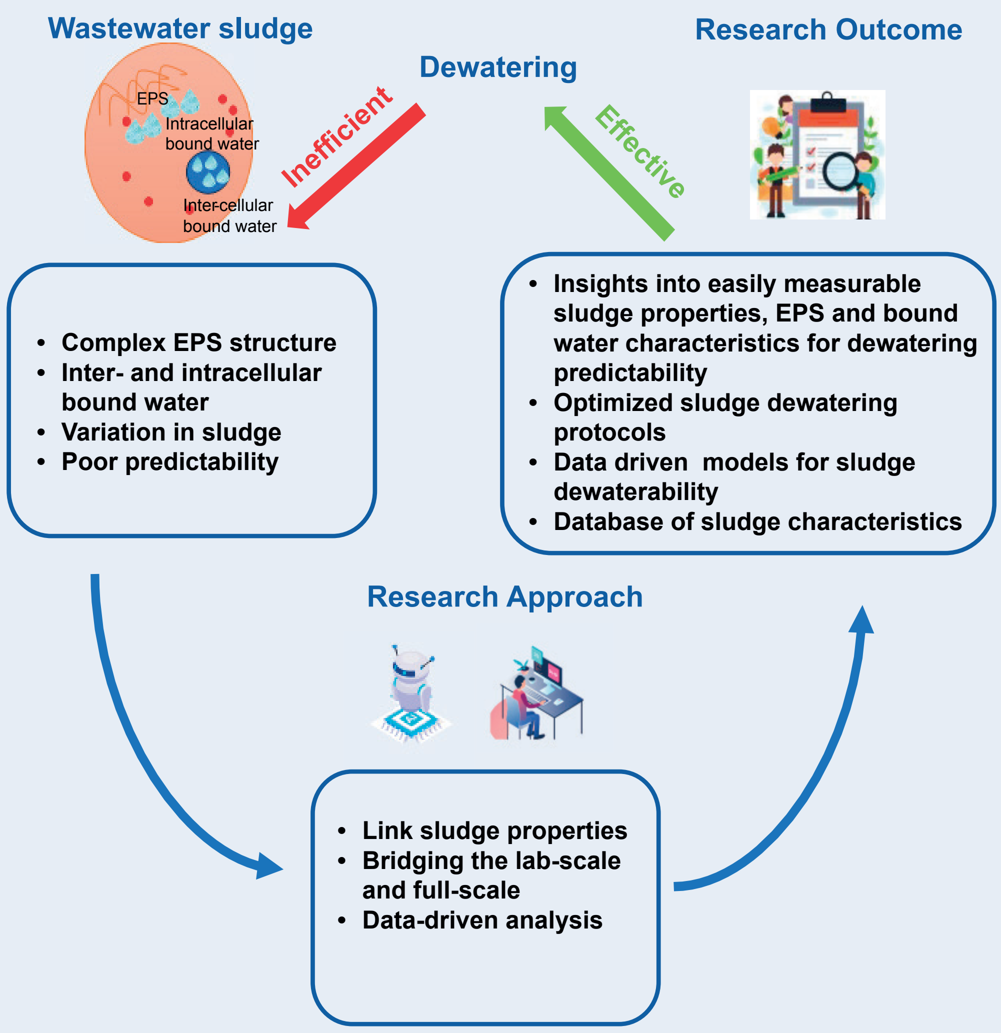

Fig 1. Graphical abstract of the research.

Addressing all these challenges require an integrated framework that links sludge properties to dewatering performance through mechanistic understanding and advanced analytical approaches.

Research goals

- Uncover key sludge properties governing dewaterability.
- Develop reliable lab-scale methodologies to predict dewaterability.
- Translate lab-scale insights into full-scale applications.
- Develop predictive data-driven models to get reliable performance benchmarks.

References

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[2] Mahmoud, A., et al, *Springer Science* (2013).
[3] Christensen, M. Lykkegaard, et al., *Water research 82 (2015): 14-24.*
[4] Wu, B., Dai, X., & Chai, X., *Water research, 180, 115912.*
[5] STOWA (2024). *Onderzoek naar het voorspellen van de ontwaterbaarheid van slib en PE-gebruik*