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Developing iron oxide adsorbents and regeneration strategies for phosphate recovery from surface water

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Motivation

Phosphorus management is key issue in wastewater treatment. While phosphorus is a vital plant nutrient crucial for agriculture, its excessive presence has well-documented detrimental effects on the natural environment, including eutrophication, algal blooms, and aesthetic and recreational impacts[1]. The Water Framework Directive required EU Member States to achieve good status in all surface water bodies by 2027[2]. Given the eutrophication threshold of 10-15 ug/L[3], it becomes important to efficiently remove phosphate during wastewater effluent polishing to mitigate eutrophication. Among the potential solutions, adsorption presents itself as a valuable approach for waters contaminated with low levels of phosphate. Given the abundance, affordability, and ease of synthesis of iron oxides, there is growing interest in employing iron minerals for phosphate recovery[4]. However, while much research focus on developing adsorbents from the adsorption perspective, the regeneration and reusability aspects still lack a comprehensive understanding. Addressing this gap in knowledge is a vital next step in advancing the field and enhancing economic viability[5]. By gaining insights into the regeneration of adsorbents, we can refine and optimize the entire process, moving closer to sustainable and efficient phosphate removal in wastewater treatment.

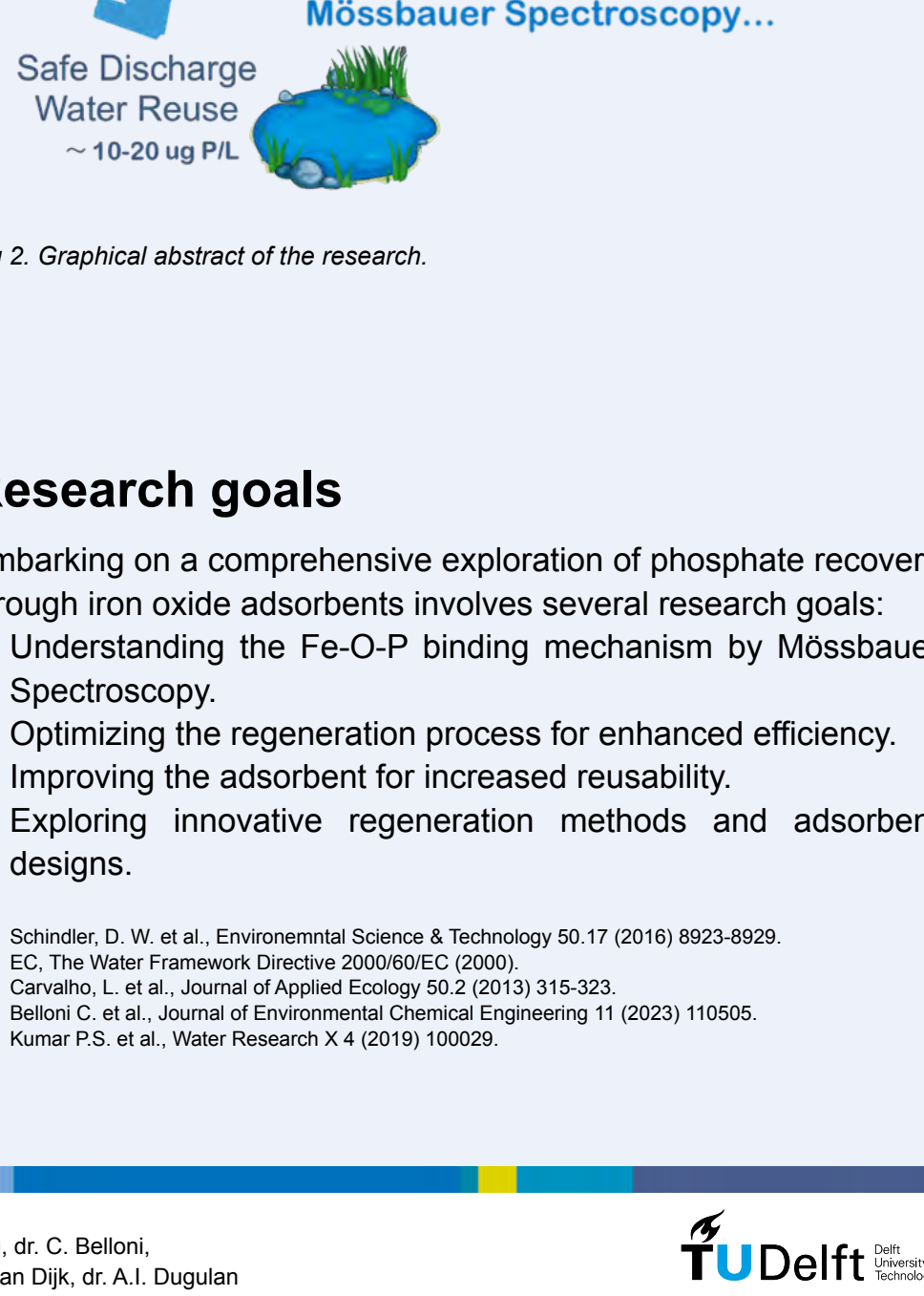

Fig 2. Graphical abstract of the research.

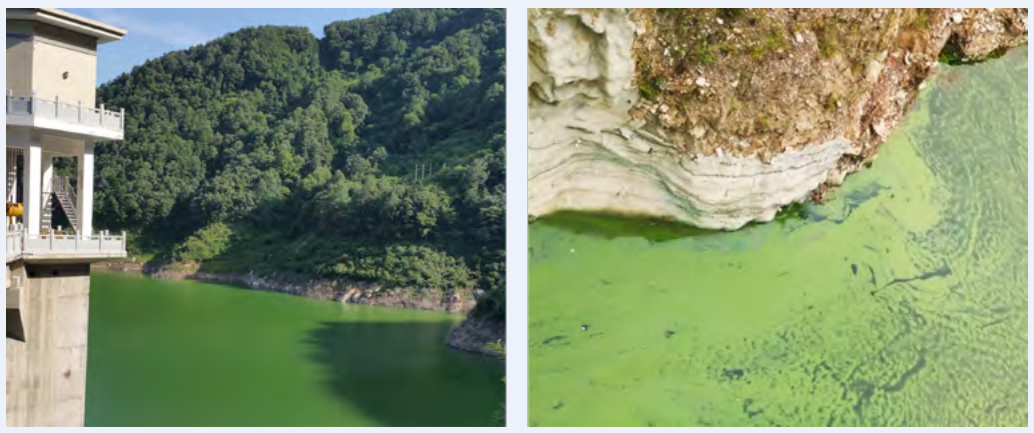

Fig 1. Eutrophic reservoir with algal bloom.

Technological challenge

Research on using iron oxide adsorbents for phosphate recovery presents several challenges. An important aspect is gaining a comprehensive understanding of the Fe-O-P binding mechanism, both bond formation and breakage, which essential for both improving the adsorption performance and optimizing the regeneration strategies. As for exploring adsorbent regeneration, the challenges including regeneration efficiency, adsorbent deterioration, dilution or loss of regenerant, and phosphate recovery. Additionally, low phosphorus levels in discharged wastewater also pose a challenge for phosphorus adsorption[5]. These challenges add to the complexity of achieving an effective and sustainable adsorption-regeneration cycle.

Research goals

Embarking on a comprehensive exploration of phosphate recovery through iron oxide adsorbents involves several research goals:

- Understanding the Fe-O-P binding mechanism by Mössbauer Spectroscopy.
- Optimizing the regeneration process for enhanced efficiency.
- Improving the adsorbent for increased reusability.
- Exploring innovative regeneration methods and adsorbent designs.

[1] Schindler, D. W. et al., Environemntal Science & Technology 50.17 (2016) 8923-8929.
[2] EC, The Water Framework Directive 2000/60/EC (2000).
[3] Carvalho, L. et al., Journal of Applied Ecology 50.2 (2013) 315-323.
[4] Belloni C. et al., Journal of Environmental Chemical Engineering 11 (2023) 110505.
[5] Kumar P.S. et al., Water Research X 4 (2019) 100029.

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