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Synergistic recovery of nitrogen (N) and phosphorous (P) from wastewater via regenerative adsorption

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Motivation

Conventional wastewater treatment processes focus on nutrient removal from sewage: carbon (C) is removed through oxidation by heterotrophs, nitrogen (N) via the nitrification/denitrification process and phosphorus (P) using enhanced biological (EBPR) or chemical (CPR) processes. While these technologies are well-established and reliable, they produce a significant amount of greenhouse gases (N_2O and CO_2) [1] and do not allow for the full valorization of the COD to offset costs. At the same time N and P are both valuable resources for agriculture and are otherwise produced through energy-intensive chemical or mining technologies. Therefore, wastewater is a largely untapped resource of N and P, and it is estimated that up to half of the demand for both nutrients can be covered by fully recovering them from wastewater [2].
Regenerative adsorption is a promising approach to realizing the circular potential of sewage, provided a synergy can be found in the recovery of N and P, and the use of chemicals necessary for regeneration and system longevity can be minimized.

Technological challenge

Generally, the regeneration part of the process when studying adsorption is comparably under-researched, while it dictates whether the use of adsorption can be economically viable to recover N and P in real sewage treatment. There is a need to explore the possibility of recovering both nutrients using a minimal amount of chemicals, while overcoming several challenges, such as the complex wastewater matrix [3], and the concentration disbalance between N and P as well as keeping an eye out for market-valuable compounds to be produced from the regenerant stream.

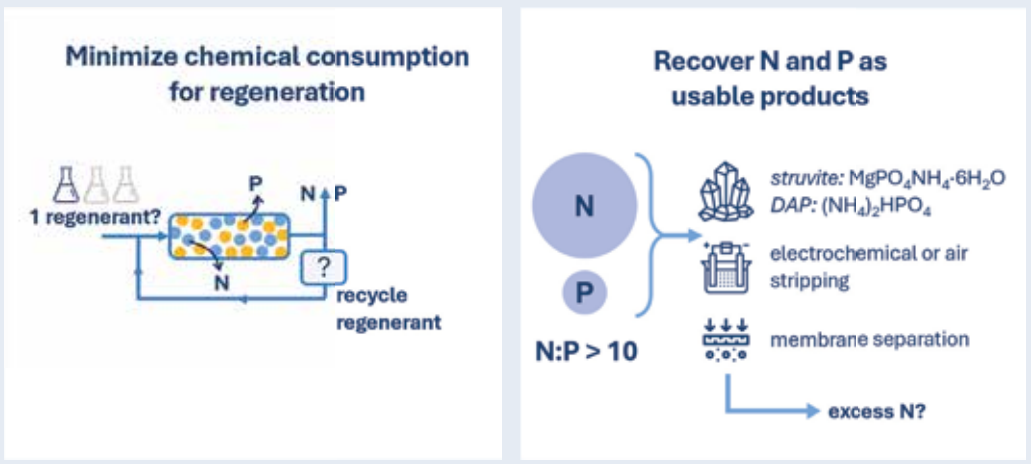
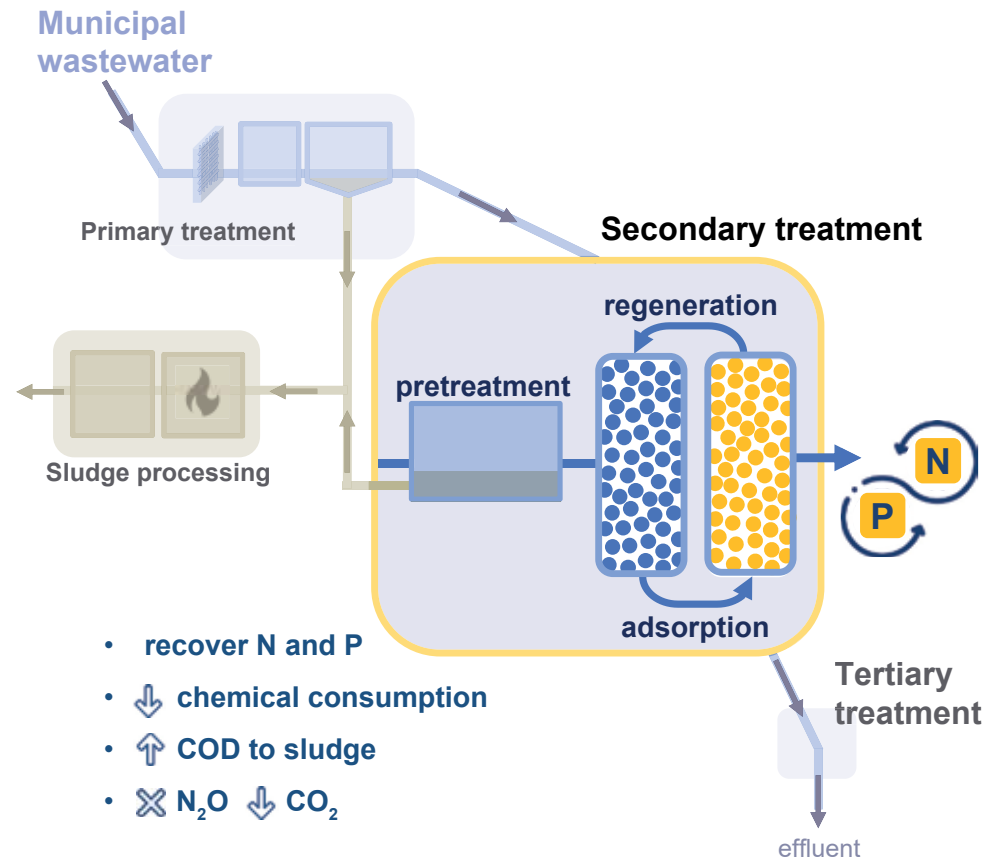


Fig. 1 Some of the main research directions of the project

Concept for the "WWTP of the future"



Research goals

- Develop a proof-of-concept method for combined desorption of N and P using a single regenerant stream exploring simultaneous and sequential processes
- Transfer the design to a complex and COD-rich realistic feedstock to evaluate the effects of the wastewater matrix on the adsorption and regeneration processes
- Identify suitable pretreatment steps, place the system in an optimal stage of existing WWTPs and/or propose what a "WWTP of the future" utilizing the system might look like
- Explore the extent of recirculation for the regenerant and approaches to prolong its reuse
- Find ways to recover the nutrients in the form of market-attractive products

References:

[1] Falk et al., Water Environment Research 85 (2013) 2307–16
[2] Schoumans et al., Ambio 44 (2015) 180–192.
[3] Kumar et al., Water Research X 4 (2019) 100029.

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