RESEARCH BRIEF
Start Date: May 01 2023 | Duration: 28 months

NAWI National Alliance for Water Innovation

# Hybrid Electrochemical-Ion Exchange Process for Selective Phosphate Recovery as Struvite

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## Challenge

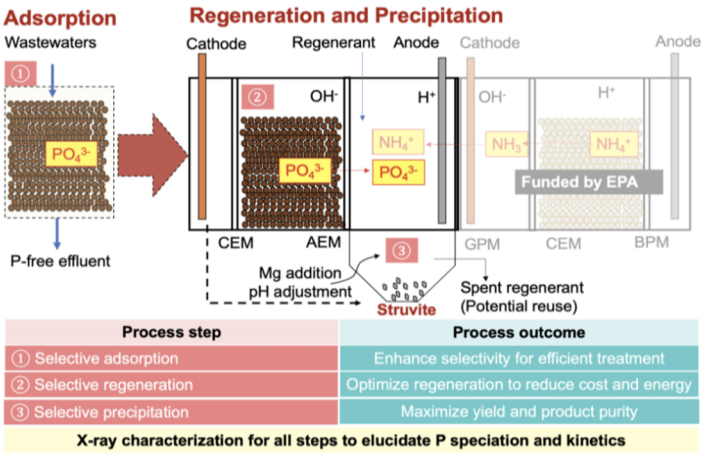
In the face of intensifying climate change, resource efficiency—maximizing the impact of every input while minimizing emissions—will play a critical role in securing California's future. California's water future will likely involve water reuse. However, phosphate in wastewater compromises the reuse of nontraditional waters by (1) contaminating water resources due to fertilizer overapplication and (2) contributing to membrane failure during reverse osmosis. Together, these effects of P increase the cost and energy of wastewater treatment and water reuse, which slows the implementation of these critical techniques to secure a robust, resilient water supply for the state of California.

## Research Approach

Innovation in a new process combining electrochemistry and ion exchange (EC-IX) will be used to address three unresolved challenges faced by state-of-art phosphate recovery technologies: (1) low product yield (e.g., struvite) limited by low phosphate concentration in wastewater; (2) low product purity limited by imprecise separation; and (3) low product uniformity limited by uncontrolled struvite precipitation in wastewater. Electrochemical ion exchange (EC-IX) directly addresses the technical and operational challenges of existing processes by concentrating phosphate into a separate environment that facilitates fine-tuned control of precipitation. We propose electrochemical regeneration, which replaces chemical inputs and their associated environmental impacts (energy, greenhouse gas emissions, tenuous supply chains) with electricity that could eventually be powered by renewables.

## Impact

This project operates at the water-food-environment nexus by producing phosphorus fertilizer (food input) from wastewater treatment while advancing water reuse and reducing environmental emissions. We achieve this through our process that leverages P-selective adsorbents to isolate phosphate from wastewater (selective adsorption), utilizes electricity as a major input to regenerate the adsorbent by eluting phosphate (selective regeneration), and extracts concentrated phosphate in a controlled environment instead of in wastewater (selective recovery). EC-IX advances P recovery from wastewater using intensified (multiple processes in one reactor), modular (flexible-scale), electrified precision separations, which lowers the cost and energy of water treatment and water reuse by reducing chemical consumption and maximizing wastewater valorization.




| Process step | Process outcome |
|---|---|
| ① Selective adsorption | Enhance selectivity for efficient treatment |
| ② Selective regeneration | Optimize regeneration to reduce cost and energy |
| ③ Selective precipitation | Maximize yield and product purity |
| X-ray characterization for all steps to elucidate P speciation and kinetics | |

**Figure 1.** A schematic of the envisioned modular, intensified electrochemical ion exchange (EC-IX) process with three major steps combined.

## RESEARCH PARTNERS

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## REFERENCES

1. H Dong, CM Laguna, MJ Liu, J Guo, WA Tarpeh (2022). Electrified ion exchange enabled by water dissociation in bipolar membranes for nitrogen recovery from source-separated urine. *Environmental Science & Technology* (link)

This work was supported by the National Alliance for Water Innovation (NAWI), funded by the U.S. Department of Energy, Energy Efficiency and Renewable Energy Office, Advanced Manufacturing Office.

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