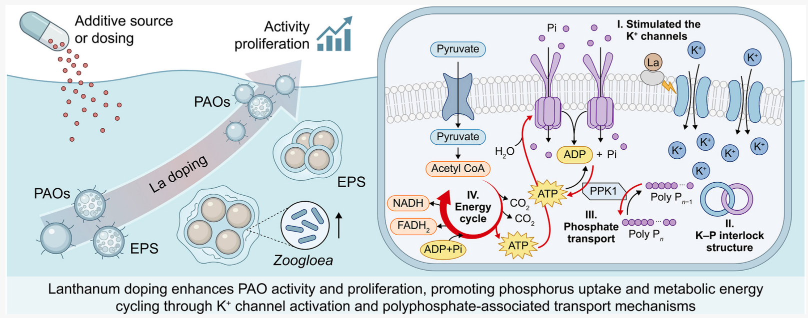
Trace lanthanum unlocks cleaner phosphorus removal

GA, UNITED STATES, June 5, 2026 /EINPresswire.com/ -- Excess phosphorus discharge remains a major cause of eutrophication, yet wastewater treatment plants often struggle to meet stricter discharge limits without heavy chemical use. A new study introduces a low-dose, slow-release lanthanum strategy that strengthens the biological engine already operating inside treatment reactors. By using lanthanum-containing aerogel beads (LZGA), the system activates polyphosphate-accumulating organisms (PAOs), improves extracellular polymeric substance (EPS)-mediated phosphorus capture, and enhances microbial energy cycling. At the optimal dose, the approach reduced effluent total phosphorus (TP) to 0.14 mg L^{-1}, offering a cleaner route to deep phosphorus removal with far lower chemical consumption than conventional advanced treatment.



Trace lanthanum activates microbial phosphorus capture.

Phosphorus from domestic and industrial wastewater can trigger algal blooms, damage aquatic ecosystems, and degrade source-water quality. Enhanced biological phosphorus removal (EBPR) is widely used because it relies on microbial metabolism and has relatively low resource demand, but its performance can fluctuate, and effluent total phosphorus (TP) may remain around 1.0 mg L^{-1}. Chemical polishing can lower phosphorus further, but often requires large doses, produces excess sludge, and may suppress the polyphosphate-accumulating organisms (PAOs) that drive biological removal. Based on these challenges, there is a need to conduct in-depth research on low-consumption strategies that can achieve deep phosphorus removal by strengthening microbial activity rather than replacing it.

Researchers from the State Key Laboratory of Urban-rural Water Resource & Environment, School of Environment, Harbin Institute of Technology, China, together with collaborators from the School of Civil Engineering and Transportation, Northeast Forestry University, China, and the School of Computer Science, Harbin Institute of Technology, China, reported the study in Environmental Science and Ecotechnology. The article was accepted on May 13, 2026, and was published online. The team developed lanthanum-containing aerogel beads (LZGA) to slowly release lanthanum ions (La^{3+}) and enhance EBPR in sequencing batch reactors (SBRs).

The team embedded lanthanum hydroxide [$La(OH)_3$] into millimeter-scale aerogel beads made with sodium alginate (SA), graphene oxide (GO), and zirconium oxychloride ($ZrOCl_2$) crosslinking, creating porous, recoverable beads that could release La^{3+} gradually. In SBRs treating domestic sewage, six LZGA doses were tested after a stabilization phase. The optimal dose was 15 mg L^{-1}, which lowered effluent TP from about 0.85 mg L^{-1} in the traditional EBPR system to 0.14 mg L^{-1} during long-term operation. Control experiments showed that LZGA alone removed only 21.1% of phosphate in solution, indicating that most of the improvement came from biological activation rather than direct chemical capture. Compared with conventional precipitation and adsorption methods, the system required only 0.7 g of lanthanum to treat one ton of wastewater, reducing chemical consumption by about two orders of magnitude. Mechanistically, La^{3+} stimulated potassium ion (K^+) channels, strengthened synchronized potassium–phosphorus metabolism, increased EPS protein content and phosphorus-binding capacity, enriched PAOs such as Candidatus Accumulibacter, and upregulated pathways linked to the tricarboxylic acid (TCA) cycle, oxidative phosphorylation, glycolysis, and phosphate transport.

The authors said the work shows that deep phosphorus removal can be achieved by "activating" the microbial system rather than overwhelming it with chemicals. They said the trace lanthanum dose appears to work like a metabolic switch: it improves ion-channel behavior, supports PAO growth, and strengthens the energy and transport pathways that help microbes capture phosphorus more efficiently. This provides a new way to upgrade existing biological reactors while keeping chemical input and sludge burden low.

The study points to a practical route for wastewater plants facing tighter phosphorus limits and rising pressure to reduce chemical use. Because LZGA beads are millimeter-scale, porous, and recoverable, they may be easier to manage than powdered lanthanum materials, which can accumulate in sludge or create local toxicity risks. The strategy also preserves the core advantage of EBPR: using microbial metabolism as the main engine of treatment. If further validated in pilot- and full-scale systems, trace-metal activation could become a broader platform for upgrading wastewater bioreactors, controlling eutrophication, and designing lower-carbon nutrient-removal technologies.

References
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