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# The use of a natural chabazite-rich zeolitic tuff improved struvite precipitation and nutrient recovery from anaerobically digested wastewater

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Both nitrogen (N) and phosphorous (P) are essential for life and their supply sustain the global population growth, thus, the question about "how correctly manage nutrient-rich wastewaters?" is a primary issue for many countries. The storage and the subsequent thoughtless use of these materials, as breeding farm and biogas plants wastewaters, has enormous impacts on the environment, causing eutrophication of water bodies and greenhouse gas emissions. The development of low-cost, low environmental impact and high yield treatment technologies is thus necessary to incentivize the circularity of resources, promoting their reuse and encouraging recycling in agri-food systems.

The recovery of N and P by struvite precipitation ($MgNH_4PO_4 \cdot 6H_2O$) is a promising strategy, but these technologies are in general too expensive, energy-demanding, or they alter the treated wastewaters, making them not suitable for agricultural purposes unless additional treatments are carried out.

This work investigates an innovative wastewater treatment processes that foresee the use of a natural chabazite-rich zeolitite (rock containing more than 50 % of zeolite minerals) in combination with struvite chemical precipitation. The adsorption batch (phase 1) is intended to improve the $NH_4^+/Mg^{2+}$ and $NH_4^+/PO_4^{3-}$ molar ratios, to enhance struvite yield (phase 2) with fewer amounts of reagents required, thus to improve both the efficiency and the cost-effectiveness of struvite production. For the 1st phase, both natural zeolitite ($N_{ZT}$) and the $K^+$-enriched ($K_{ZT}$) zeolitite were tested. $K_{ZT}$ was intended to counteract any possible interference for struvite precipitation, which could instead happen with $N_{ZT}$ due to the input of $Ca^{2+}$ ions in solution.

In the 2nd phase (struvite precipitation), 2 different $Mg:NH_4:PO_4$ molar ratios were tested, in particular a condition of $NH_4^+$ excess (MR1) and a condition with $Mg^{2+}$ in excess (MR2).

Treatments in which $N_{ZT}$ (NZT-S) and $K_{ZT}$ (KZT-S) were added prior to struvite precipitation were compared to a conventional struvite precipitation method without the use of zeolitites (CNTR).

NZT-S_MR1 was found to be the most feasible strategy because of the highest $NH_4^+$-N removal efficiency, highest struvite precipitation efficiency (less waste of reagents), and less unwanted

alterations of the treated wastewater. The precipitate obtained was 89.9 mass % composed of struvite with 3.5 % N, poor in hazardous heavy metals.

The $NH_4^+$-N removal efficiency was in order: NZT-S > KZT-S > CNTR, with the highest reduction of 84.8 % recorded by NZT-S_MR1 and the lowest recorded by the CNTR (67.2 and 75.0 % for MR1 and MR2 respectively).

The addition of a “zeolite phase” in struvite precipitation process thus represents i) a valuable method for improving the efficiency of struvite production ii) a method for saving chemical reagents in struvite production and iii) an efficient way to recover and recycling N in agriculture.