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Magnetic Vivianite Recovery from Sewage Sludge

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Motivation

Phosphorus is one of the most important elements constituting life and acts as the limiting major component for plant growth. Currently, Europe is highly dependent on the import of phosphorus. Meanwhile, the mining process of phosphate rock is polluting and its linear use can lead to eutrophication problems. Phosphate recovery ensures resource preservation, food security and political independence in the future. Sewage sludge is an attractive secondary source for phosphate recovery, with the ability to cover 20 – 30% of Europe's fertilizer demand[1].

Recently, it was discovered that in wastewater treatment plants dosing iron to remove phosphate, up to 90% of phosphorus in sludge is present as vivianite ($Fe_3(PO_4)_2.8H_2O$)[2]. This mineral is thermodynamically and kinetically favored in reduced environments like excess sludge and anaerobic digester. Since vivianite is paramagnetic, its recovery from sludge is possible with magnetic technology originating from the mining industry. This research aims to understand the characteristics of vivianite in relation to its separation, optimize the recovery efficiency and explore the best valorizations for the recovered vivianite.

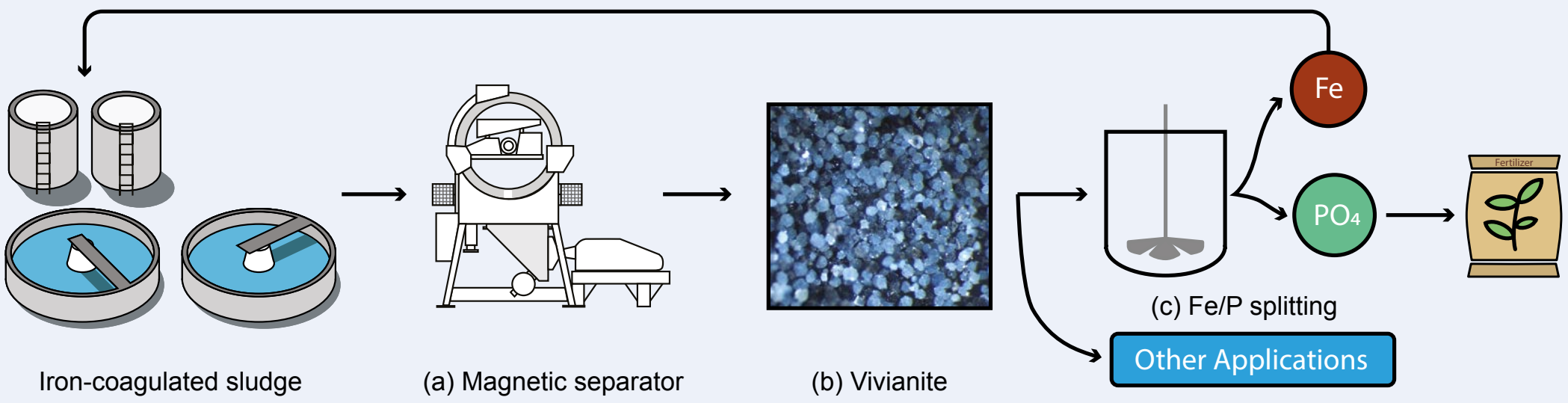

Fig 1. Schematic overview of the phosphate recovery via vivianite process. The project focuses on: (a) the optimization of the magnetic separator, (b) vivianite properties (color changes from transparent to dark blue as oxidation occurs), (c) splitting Fe/P and circular use of Fe and other applications.

Technological challenge

The recovery of vivianite is strongly tied to its quantification and identification. The fact that vivianite is prone to oxidation makes it more difficult for accurate quantification, even for the best technique available like Mössbauer spectroscopy. Moreover, oxidation could also affect its magnetic recoverability.

Magnetic separation was proven to successfully recover vivianite from sewage sludge [3]. However, there are discrepancies in recovery efficiencies that require deeper understanding.

Lastly, the valorization of vivianite is necessary to close the resource recovery loop. Splitting iron and phosphate is an option that would enable the reutilization of Fe in a circular way. However, the process still needs optimization. Additionally, creative ways to use vivianite can make the technology economically viable.

Research goals

- Improve vivianite quantification (e.g., with Mössbauer spectroscopy).
- Investigate the influence of vivianite properties (e.g., oxidation, particle size) in relation to its extraction from sludge.
- Understand the influence of sludge characteristics (e.g., viscosity) and operational parameters on magnetic separation efficiency.
- Optimize Fe/P separation for circular use of Fe, for example, by alkaline leaching or via electrochemical processes.
- Explore alternative applications of vivianite.

[1] Van Dijk, K. C. et al. (2016). Phosphorus flows and balances of the European Union Member States. Science of The Total Environment, 542, 1078–1093.
[2] Wilfert, P. et al. (2018). Vivianite as the main phosphate mineral in digested sewage sludge and its role for phosphate recovery. Water Research, 144, 312-321.
[3] Prot, T. J. F. et al. (2019). Magnetic Separation and Characterization of Vivianite from Digested Sewage Sludge. Separation and Purification Technology, 224,564-579

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