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Phosphorus recovery from iron phosphate containing sewage sludge

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Motivation

Phosphorus is an essential nutrient for plant growth, but at the same time the resources of phosphate rock are limited and concentrated in a few countries outside Europe. Linear use of phosphorus also creates environmental problems like eutrophication and wastes. Recovery can help to secure access to phosphorus for food production. Sewage sludge and manure are the most important potential sources for recovery of phosphorus.

Fig.1. Sludge in the aeration basin of a WWTP

Fig.2. Fertilizer is spread on crops

The majority of municipal wastewater treatment plants (WWTP's) use iron salts to co-precipitate iron phosphates. This method of operation is popular as it presents low investment costs and is easier to operate. Incineration is the only available method to recover phosphate from these types of WWTP's.

Unfortunately, this technique presents limitations like the lack of ash treatment facilities and the required investment costs to realize an incineration facility. The objective of this research is to develop a new technology for recovery of phosphorus from these sludges.

Recently it has been found that almost all phosphorus in sludge is present as vivianite, provided that enough iron is present and the sludge is digested. This discovery opened new perspectives for phosphorus recovery from sludge and possibly also for manure. This places vivianite central in this project.

Fig.3. Vivianite crystals from a natural environment

Technological challenge

The presence of vivianite in sludge has been reported in literature but the mechanism of its formation in sludge is unclear and has never been studied. Recent information indicate that the particles are small (max 100µm) and are most likely impure. Therefore the analysis of such small particles in a complex matrix like sludge will be challenging.

1. P.S. Kumar, P. Wilfert, L. Korving, G.J. Witkamp, M.C.M. Van Loosdrecht, "The relevance of phosphorus and iron chemistry for phosphate recovery from sewage: a review", Environmental Science and Technology 49, 2015, Pages 9400-9414
2. E. Frossard, J.P. Bauer and F. Lothe, "Evidence of vivianite in FeSO4 flocculated sludges", Water Research 31, 1997, Pages 2449-2454
3. P. Wilfert, Unpublished results

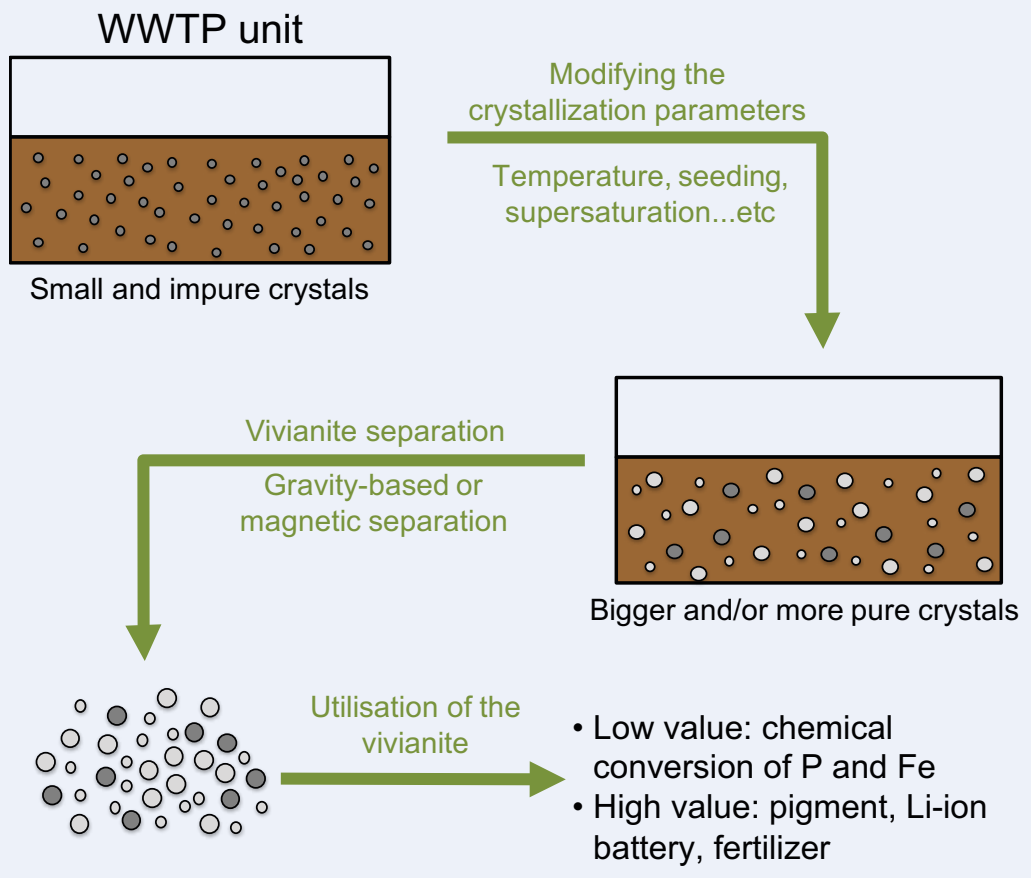

Fig.4. Graphical abstract of the project

Technologies for recovery of struvite ($NH_4MgPO_4*6H_2O$) from sludge are already developed (Airprex principle for instance) but are not applicable for the recovery of vivianite since the vivianite particles found in sludge are too small.

However, extraction of vivianite from sewage sludge is, for instance, possible through magnetic separation. The extraction efficiency is currently low but increasing the particles size or the purity of the product may enhance it as well as open new separation opportunities like the use of gravity-based technologies.

Research goals

- Understand the crystallization process of vivianite through the study of rates and mechanisms of the nucleation, growth and agglomeration to increase the purity and size of the vivianite crystals.
- Understand the mechanisms behind the oxidation of vivianite in order to find working conditions preventing vivianite oxidation.
- Propose an efficient and cost-effective method for vivianite separation from the sludge.
- Develop ways to utilize the harvested vivianite taking into account the purity of the recovered product.

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