Prevention of Struvite Scaling in Digesters in Combination with Phosphorus Removal and Recovery
- The FIX-Phos Process -

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Introduction

Anaerobic digestion of sewage sludge from enhanced biological phosphorus removal plants (EBPR) often leads to operational problems:

→ Scaling of struvite ($MgNH_3PO_4 \cdot 6\ H_20$) in digesters and pipe works (figure 1).

→ High phosphorus return loads from anaerobic sludge dewatering.

→ Poor dewaterability of phosphorus rich anaerobic sludge.

Figure 1: Struvite scalings in WWTP with enhanced biological phosphorus removal are a common operational problem

A frequent strategy to reduce struvite formation is the addition of iron salts into the anaerobic digester. This may cause other problems:

→ Formation of vivianite scalings.

→ A decreased sludge quality (low plant availability of P) which is counterproductive in case of land spreading of biosolids.

→ An increased sludge volume.

Figure 2: CSH is mixed with waste activated sludge during a full scale test before the CSH/sludge mixture is fed into the digester.

The FIX-Phos process

In this context a new approach has been developed and patented that ***combines struvite prevention and phosphorus recovery***: Calciumsilicatehydrate (CSH) containing particles (a by product from the production of gas concrete) are added to the sewage sludge during anaerobic treatment. The CSH releases Ca^{2+} accompanied by a raise in the pH value which triggers the formation of calcium-phosphates (Ca-P) (figure 3). CSH is converted into Ca-P and the concentration of dissolved phosphorus in the sludge water decreases (figure 5).

The Ca-P particles with a phosphorus content of 8 – 10 wt% can either remain in the digested sewage sludge (in case of land application) or alternatively be separated after digestion for reuse as phosphorus fertilizer (figure 6). Tests on laboratory (figure 4) and full scale (figure 2) have shown that the *addition of CSH* has no negative impact on anaerobic digestion.

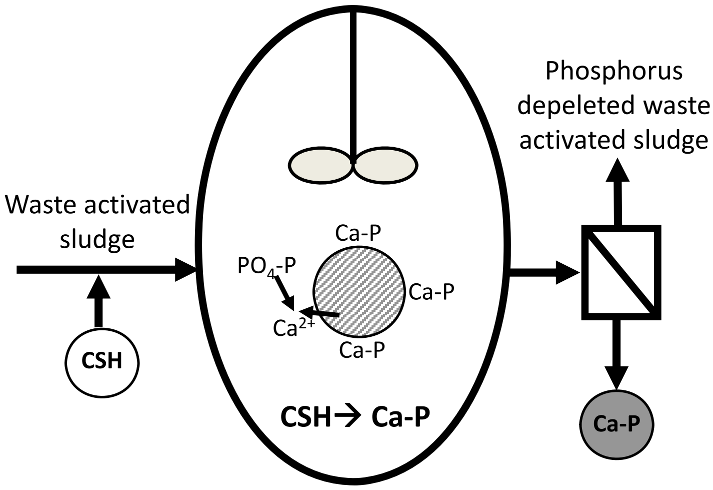

Figure 3: Flow chart of the FIX-Phos process with phosphorus recovery. The CSH is added to waste activated sludge which is treated separately from primary sludge.

The CSH could be integrated at various stages of the sludge treatment process:

1) Separate digestion of primary and secondary sludge

If a separate digestion of primary and waste activated sludge in two different digesters is possible, the CSH could be added to the reactor treating the waste activated sludge, eventually followed by a separation and recycling of the Ca-P (figure 3). In this case CSH with a grain size of 1 – 1,5 mm could be used which facilitates the separation of the Ca-P recovery product.

2) Addition to waste activated sludge in a pre-treatment

If a separate digestion of primary sludge and waste activated sludge is not possible and phosphorus recovery is desired, CSH can also be added to pure waste activated sludge in an anaerobic pre-treatment step followed by the separation of the Ca-P recovery product (figure 6) and a joint anaerobic treatment of primary sludge and the phosphorus-depleted waste activated sludge. The advantages are a short hydraulic retention times (HRT) of the pre-treatment step and thus smaller reactor volumes.

3) Addition to a conventional anaerobic digester

As a third alternative the CSH can also be added straight to a conventional anaerobic digester treating raw sewage for struvite control and P-recovery. If a separation of the CSH is not desired, smaller grain sizes of 0,1 – 0,5 mm should be applied to prevent the sedimentation of the Ca-P.

Figure 4: 150 L laboratory digesters that were used for the development of the FIX-Phos process

Laboratory and first large scale experiments

The different configurations have been tested in lab scale experiments in anaerobic reactors using primary sludge and waste activated sludge from a WWTP which employs the EBPR process (figure 4). The PO_4-P concentrations in the sludge water were reduced effectively in all reactors due to the addition of CSH (figure 5). Recovery rates of 25 – 40 % of total P can be achieved depending on the configuration.

Currently the first large scale application (2012) is under preparation.

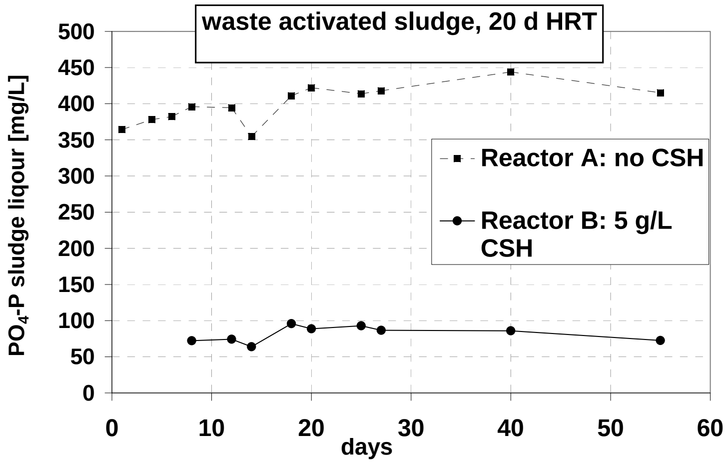

Figure 5: PO_4-P concentration in a reactor treating pure EBPR waste activated sludge (A) and a reactor with CSH addition (B)

The Ca-P recovery product

The phosphorus content of the recovered product ranges between 8 – 10 wt.% and mostly consists of Ca-P. The product also contains Magnesium which is removed from the liquid phase. The heavy metal content is very low and the product can be readily reused as P-fertilizer.

Figure 6: Separation of the Ca-P recovery product from waste activated sludge after anaerobic treatment

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