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Optimisation of struvite precipitation from urine on bench scale

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INTRODUCTION

Urine contains more than 50 % of phosphorus and 80 % of nitrogen of the daily excreta. Therefore recovery and reuse of these nutrients from urine is an interesting alternative to chemical fertilisers. One common method is the addition of magnesium to precipitate struvite (magnesium ammonium phosphate = MAP). The chemical reaction occurring is:

$$Mg + NH_4 + PO_4 + 6\ H_2O \rightarrow (MgNH_4PO_4 * 6\ H_2O)\downarrow$$

Laboratory experiments were conducted to optimise struvite precipitation. The results were transferred to a bench scale reactor.

MATERIAL AND METHODS

Urine of source separating toilets and waterless urinals from a GIZ office building is collected and stored for at least 2 weeks. Thus, the urine is hydrolysed and pH rises to 8.5-9. In total a capacity of 8000 l of urine can be stored.

Magnesium oxide (MgO) was used as magnesium source. Magnesium dosing experiments took place in glass beakers with hand stirrer and 250 ml of urine. Stirring time was three times 30 s with 30 s break in between and sedimentation time of 180 min. These were the same conditions as in the reactor experiments. For the sedimentation experiments 1 l Imhoff glass beakers were used. Phosphate concentration was between 530 and 545 mg PO_4 l^{-1} (5.6 to 5.8 mmol l^{-1}) in urine. All samples were filtered through 10 µm Whatman folded filters.

The precipitation reactor ("NuRec", by HUBER SE, figure 1) works in batches. Urine (30-50 l) is running into the precipitation reactor by gravity flow. MgO is added in water soluble plastic bags. After stirring a sedimentation phase of 3 hours follows. Then 5 l of the supernatant is filtered through 10 µm filter bags made of polypropylene. The rest of the supernatant is filtered through a second bag. The bags were dried at about 35°C for 4-5 days to get a dry fertiliser product.

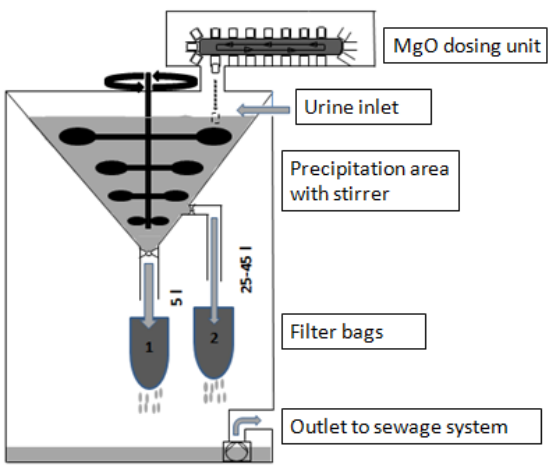

Figure 1: Drawing of the "NuRec" precipitation reactor with filter bags and MgO-dosing unit

RESULTS AND DISCUSSION

Laboratory experiments show almost no difference between filtering the supernatant with or without the formed struvite. In reactor experiments the supernatant still contains up to 60 % of phosphorus and thus drastically reduces the recovery of phosphate.

In order to precipitate phosphate to a high degree, magnesium has to be overdosed stoichiometrically. This is expressed in the β-factor, where β=1 represents stoichiometrically dosing. A β-factor of 1.5 (50 % overdosing of magnesium) is sufficient to precipitate and recover up to 99 % of phosphate in laboratory experiments and 95 % in reactor experiments (see figure 2).

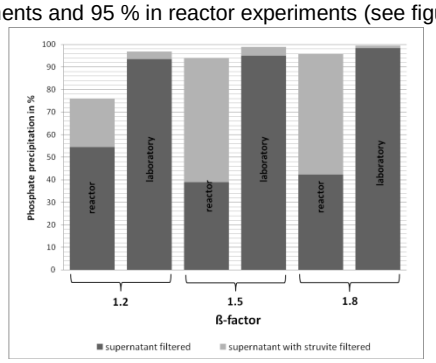

Figure 2: Influence of ß-factor on phosphate recovery for supernatant filtered and supernatant filtered with struvite in laboratory and reactor experiments

In order to run the precipitation reactor economically, time for sedimentation should be as short as possible. After one hour most of the phosphate is already precipitated and sedimentated (see figure 3); longer sedimentation times only increase the recovery slightly (less than 5 %). Also the amount of phosphorus in the supernatant remains constant. This indicates that some of the phosphate did not react with MgO. In the supernatant filtered with struvite already crystallised struvite works as a seeding material and thus enhances the recovery in the reactor experiments.

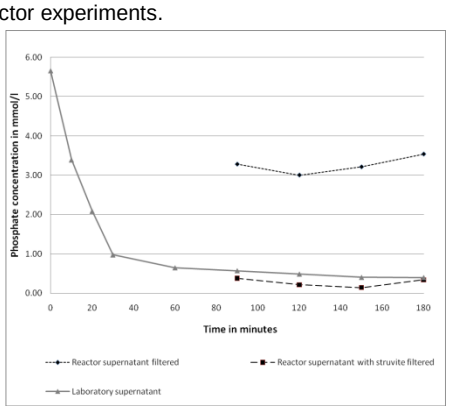

Figure 3: Influence of sedimentation time on phosphate concentration in supernatant for laboratory and reactor experiments and for supernatant filtered with struvite for reactor experiments, β-factor = 1.5

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