The main innovation goal of the BioDEN project is to realise an extensive valorisation of the nitrogen and phosphorus-rich digestate originating from anaerobic digestion into existing and new bio-based fertilisers. In this manner BioDEN creates an opportunity to realise a closed nutrient cycle and offers a possible escape from the high artificial fertiliser prices. More specifically, techniques such as (vacuum)stripping of ammonia in combination with acid scrubbing, and phosphorus absorption and adsorption are tested in both lab- and industrial settings.

The BioDEN project kicked off early January 2022 and spans 28 months. It is a collaboration between Biogas-E, KU Leuven, UGent, Marmara University, VCM and Ostim Enerjik. This article provides an update on the work undertaken in the meantime.

Marmara University investigated two different techniques to recover phosphorus (P) from the liquid fraction of digestate (LFD): struvite crystallization and adsorption on Fe-modified biochar.

Struvite crystallization

Initially, struvite crystallization was tested to recover phosphate from chicken manure (CM) digestate. Struvite crystallization experiments were conducted in batch-mode using a laboratory scale 4,5 L upflow reactor (UR) filled with 3,5 L liquid fraction of CM digestate. The LFD was circulated from the bottom of the UR with an upflow velocity of 20 cm/min for 24 h. As Mg source $MgCl_2$ was supplemented, with a Mg:P molar ratio of 1:1, at the beginning of the experiment. As a result, almost 80% of the phosphate was removed in 24 hours whereof 75% of the crystallization was accomplished during the first hour.

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Biochar adsorption

Biochar has emerged as a potential alternative material for adsorbing and recovering phosphate from waste streams. However, the capacity of raw biochar to adsorb phosphate is relatively low. To enhance its phosphate adsorption efficiency, biochar is generally modified with iron. Biochar was produced from ground corn cob by pyrolysis at 550 °C for 2 h in a nitrogen atmosphere and modified with the method described by Yang et al. (2018). To assess the phosphate adsorption performance of iron-modified biochar on CM digestate, a series of batch tests were carried out using various biochar dosages (2, 4, 10 g/L). 50 mL CM digestate with a PO_4^{-3}-P concentration of 230 mg/L was filled in 100 mL glass flasks without pH adjustment. Flasks were shaken for 90 min. With increasing adsorbent dosage, P recovery efficiency increased up to 40% and the maximum adsorption capacity was 17 mg P/g biochar dosed. Experiments will be repeated with higher dosages to obtain higher P recovery.

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On the agenda

In the final stage of the study, struvite crystallization experiments are carried out in pilot scale in the facility of Seleda Biyogaz Enerji San. ve Tic. A.Ş. in Babaeski, Kırklareli, Türkiye. The schematic and photograph of the pilot-scale continuously fed upflow struvite crystallization system is shown in Figure 1. The experiments are ongoing and the results will be presented in the next newsletter. **Take a sneak peek at the pilot scale crystalliser in [this video](#).**

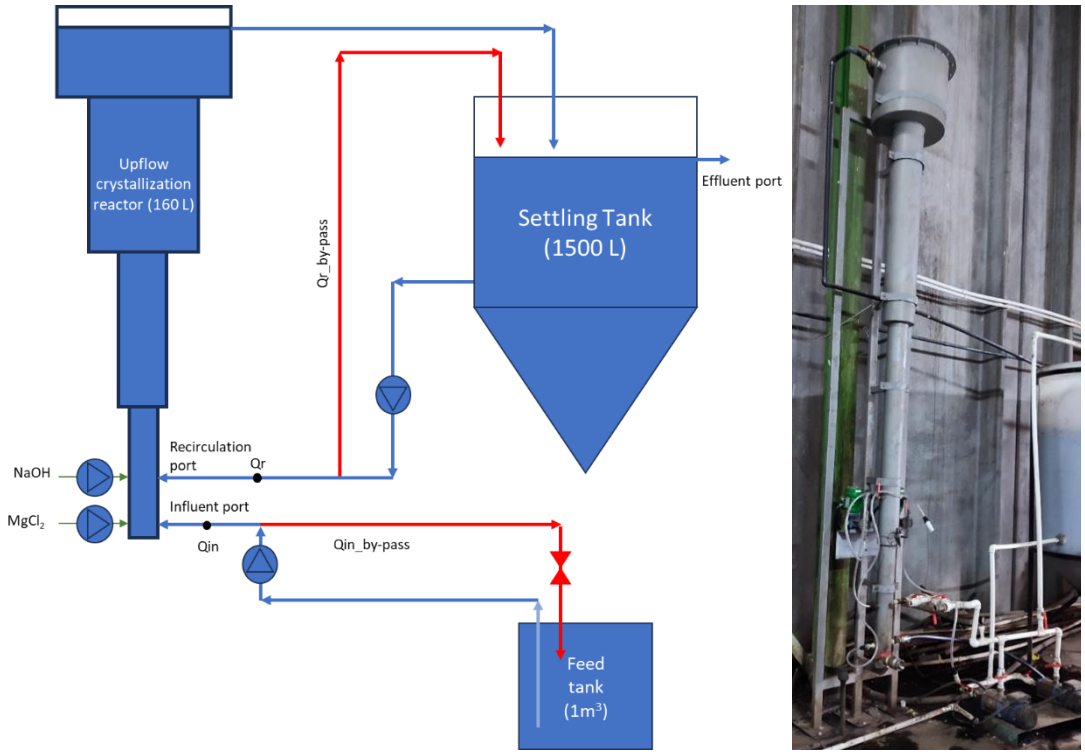

Figure 1: Schematic and photograph of pilot-scale struvite crystallization set-up, ©Marmara University.

Ghent University is performing pot trials to test the agronomic performance of P-fertilizing products on ryegrass (*Lolium perenne*) and the nutrient-poor product resulting after N-stripping and P-leaching tests will be assessed for its soil-enhancing properties. KU Leuven will process the data resulting from the full scale tests.

Finally, the available results will be applied by VCM and Biogas-E to carry out an economic, technological and ecological analysis of recovery options. For this purpose, six unique technology cascades are composed. Only experiments conducted on the same input stream are combined into the same cascade. The six different cascades are shown in Table 1.

Table 1: The six different technology cascades.

Cascade	Input	Biogas ↑	N-recovery	P-recovery
1	Dairy manure	Post-AD	Stripping-scrubbing	/
2	Pig manure	/	/	P-leaching
3	Dairy manure	Post-AD	Stripping-scrubbing	P-leaching
4	Organic waste	Post-AD	Stripping-scrubbing	/
5	Chicken manure	Vacuum stripping		Struvite
6	Chicken manure	Vacuum stripping		Biochar

Would you like more information about the BioDEN project in general or would you like to follow the project more closely? Contact: info@biogas-e.be

With the support of:

References

Yang, Q., Wang, X., Luo, W., Sun, J., Xu, Q., Chen, F., Zhao, J., Wang, S., Yao, F., Wang, D., Li, X., Zeng, G. (2018). Effectiveness and mechanisms of phosphate adsorption on iron-modified biochars derived from waste activated sludge. Bioresour. Technol. 247, 537-544.