STØTTET AF
Promilleafgiftsfonden for landbrug

Phosphorus filters as a mitigation tool to achieve the Danish climate goals for agriculture

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Phosphorus a challenge for the agricultural climate goals

Denmark is aiming at reducing agricultural greenhouse gas (GHG) emissions with 1,9 million tons of CO_2e by 2030. The Danish agricultural GHG emission is estimated to be 17,5 million tons CO_2e. The largest contribution of 32% (5,6 million tons CO_2e) originates from cultivated peatlands, though these soils represent less than 7% of the cultivated area.
Consequently, Denmarks aims at rewetting 50.500 ha of peatland soils. However, the risk of remobilization of phosphorus (P) is currently blocking 33% of all rewetting projects, thus making it difficult to reach the climate goal.

Previous studies with compact P-filters in Denmark have shown a monthly removal rate for TP varying between -33 to 88%, with an average removal of 61% indicating an acceptable average efficiency. However, so far pilot filter systems treated drainage water from a few hectares only. The FosLav project (2022-2025) upscale P-filters to determine their suitability when applied at field scale.

Study sites and system design

The project entails three study sides across Denmark. Two of the areas are peatlands and one area consists of drained mineral soil. Based the on initial analysis of soil and water chemistry different combinations of particle filters from WaterCare Aps, electro-flocculation devices from Bio-Aqua A/S, and reactive filters from DiaPure AB have been combined and are now being evaluated in relation to the retention of both particular and dissolved P.

Figure 1: Test locations across Denmark

Study site characteristics

- Vejrumbro: Peatland soil with an almost equal ratio of dissolved and particulate P in high concentrations
- Fensholt: Drained mineral soil with a high ratio of particulate P
- Løvenborg: Peatland soil, with low-medium P-concentration and a high ratio of dissolved P

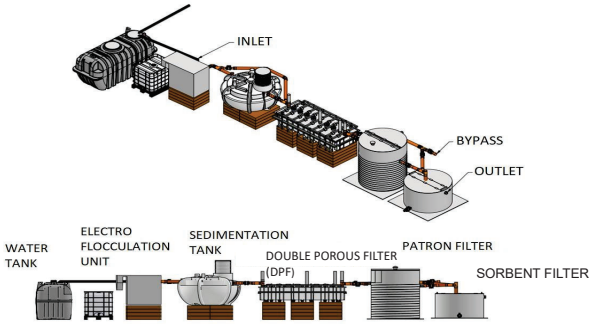

Figure 2: Schematic drawing of the P-filter installed at Vejrumbro

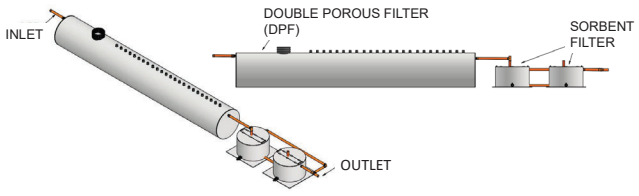

Figure 3: Schematic drawing of the P-filter installed at Fensholt

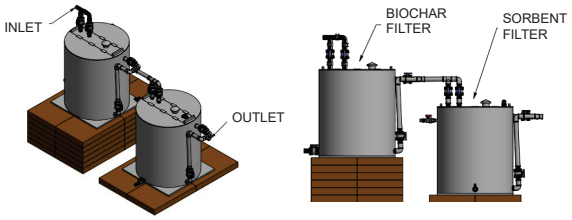

Figure 4: Schematic drawing of the P-filter installed at Løvenborg

Water sampling and analyses

Water samples are collected after each filter component to determine the effect of the individual filter components and the whole filter system.
Total P (TP) and total dissolved P (TDP) are determined colorimetrically after persulphate digestion in an autoclave. For TDP samples are filtered through 0.45 µm cellulose-acetate membrane filters. The difference between TP and TDP is considered particulate P (PP).

Initial results

So far initial results have primarily been obtained at the Vejrumbro and Fensholt sites where testing of units for PP retention began in the winter 2022/2023.

Vejrumbro

- PP in the inlet water comprised 40-60% of the TP; average TP concentration was 0.2 ppm.
- The initial setup retained 33% PP and 21% TP at a hydraulic retention time of *ca.* 2.5 hours in the filter line (electro-flocculation + sedimentation tank + DPF).
- DOC was little retained in the filter line posing a challenge for coupling a reactive filter with P binding material to the system. The long-term retention capacity for PP of the DPF is another bottleneck which will be addressed during the project.

Small-scale electro-flocculation test

The potential of electro-flocculation (EF) was evaluated in a small-scale experiment testing the combination of an Fe electrode and an organic coagulant (Chitosan) in filter line similar to Vejrumbro. To simulate treatment water with a high concentration of P and DOC, effluent from a woodchip bioreactor was used with an initial TP concentration of 15 ppm declining somewhat with time.

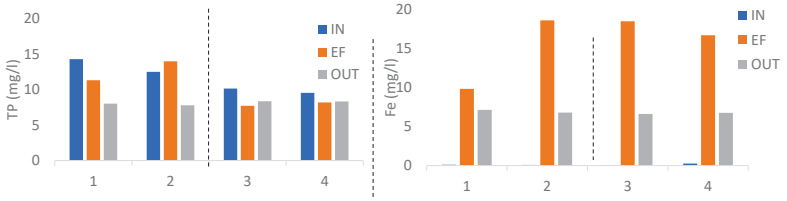

Figure 5: Total phosphorus (TP) and total Iron (Fe) concentration at the inlet (IN, woodchip effluent), in the EF unit, and the outlet of the sedimentation unit (OUT).The dashed line indicates when addition of Chitosan was stopped. Numbers on x-axis show repeated samplings each an hour apart before and after Chitosan addition. Sampling commenced after two system volumes were exchanged.

Electro-flocculation generated high Fe concentrations and up to 60% of Fe was retained before the outlet at 3.5 h hydraulic retention time (HRT). EF plus Chitosan achieved TP retention of *ca.* 40%, while EF alone only retained 10% of TP. In the latter case, little extra retention occurred in the sedimentation unit with *ca.* 3 h HRT.

Fensholt

- From February – May 2023 the system has continuously treated 4000 - 6000 L of water pr. hour.
- TP concentration varied between 0.05 – 0.6 ppm (flow-weighted 0.09 ppm); 44% PP.
- The average retention of TP and PP was resp. 52% and 67% for the DPF unit.

Conclusion

The initial testing at Vejrumbro and Fensholt indicates a substantial potential of PP retention in P filters. However, it is important to design and adjust the filters to the local conditions and particularly soil characteristics. High DOC loads from peatlands remain a big challenge; likewise limited retention time in compact systems. more information is still needed in relation to the sorbent filters which will first be tested in the fall/winter of 2023.

Whether compact P filters are a feasible mitigation tool that can decisively reduce drainage water P loads in Denmark will depend on the cost-effectiveness of filters, which will also be evaluated in the FosLav project.

Want to know more about the FosLav Project?

For more information regarding the FosLav project and the projects results pleas visit the project home page on LinkedIn " FosLav - Kompakte filterløsninger til minimering af fosfortab til vandmiljøet"

https://www.linkedin.com/showcase/foslav/

Acknowledgment

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