Interreg
North Sea Region
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EUROPEAN UNION

FILTER SYSTEMS FOR A SUSTAINABLE AGRICULTURE

FIELD CASE DESCRIPTION

Phosphorus filter system for agricultural drainage water (second field case)

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Location

Country: Denmark
City: Odder
Coordinates: 55.996127 - 10.101370

Problem description

Phosphorus (P) leaching from tile-drained agricultural land contributes to diffuse pollution of surface waters. Critical P losses occur on hot spot areas where P-enriched soils are linked to a sensitive recipient by an effective hydrological process. As the scope of agronomic mitigation is limited, there is a need for end-of-pipe solutions. Phosphorus is transported in dissolved and particulate form (DP, PP), both of which have to be retained by an effective filter system.

Filter description

A full-scale experimental drainage P-filter system was established at the Fensholt catchment and near the town of Odder, Denmark. The system is fed with tile drainage water from an arable field of ca. 25 ha with loamy soils that had developed on Weichselian glacial till. The filter system is dimensioned to handle only part of the drainage water (8.3% of the drainage runoff in the first half of 2020).
The filter system consists of the following main units:
- a pump feeding drainage water from the collector drain into the filter system at flow rates of typically 1 – 1.5 l/s.
- a WaterCare A/S DPF sediment filter of 1000 l capacity which has the function of retaining small particles and thus particulate P.
- Krohne™ electromagnetic flowmeter that measures the actual amount of water transported through the WaterCare A/S sediment filter unit.
- a flow divider for directing ca. 10% of the incoming drainage water to the reactive filter for dissolved P.
- a CGK group BV filter box containing 50 kg of iron coated sand (ICS).
- a flow meter at the outlet of the filter box.
Three ISCO™ samplers for continuous automated water collection are positioned at the inlet (ISCO1), between the sediment and reactive filter (ISCO2) and at the outlet (ISCO3). Total P (TP), total dissolved P (TDP), turbidity, pH and EC are measured in the lab on time proportional samples.

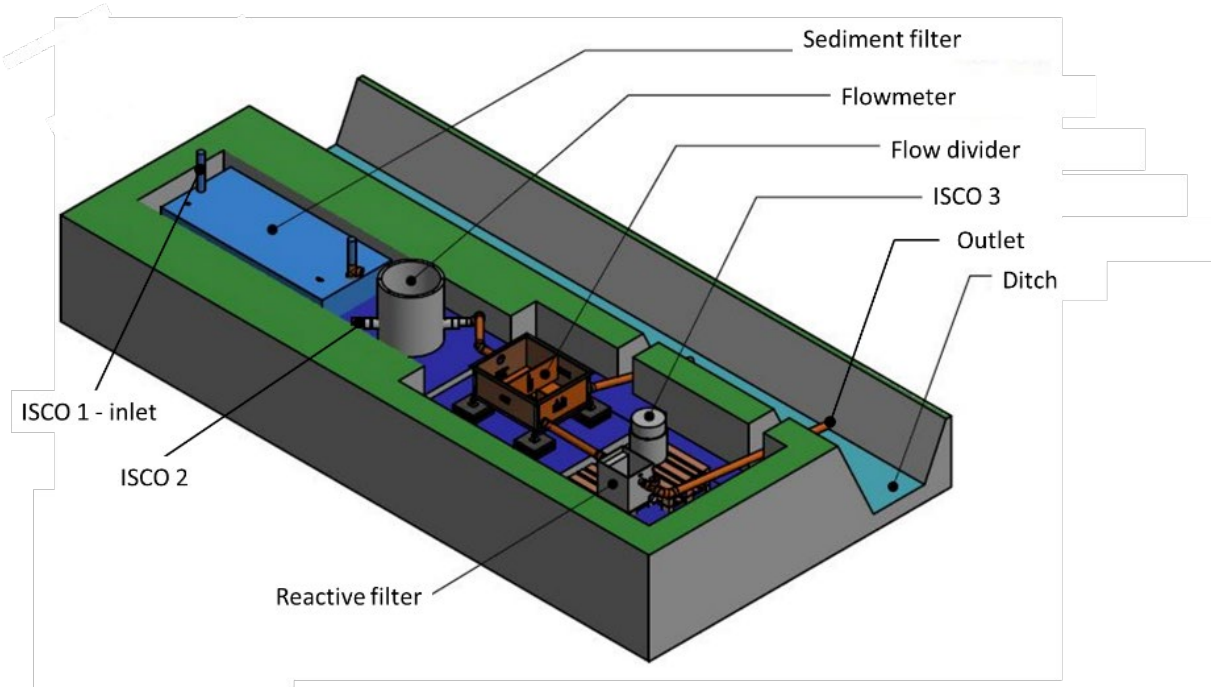

Figure 1 Schematic drawing of the drainage P-filter system

Visual impressions of the filter system

Figure 2 Drainage P-filter system near Odder, Denmark.

Figure 3 WaterCareTM prefilter for retaining sand and larger particles (right) and DPF sediment filter (left) during installation.

Figure 4 Flow divider

Figure 5 Filter box with reactive ICS filter

Results

Drainage season 2020-2021

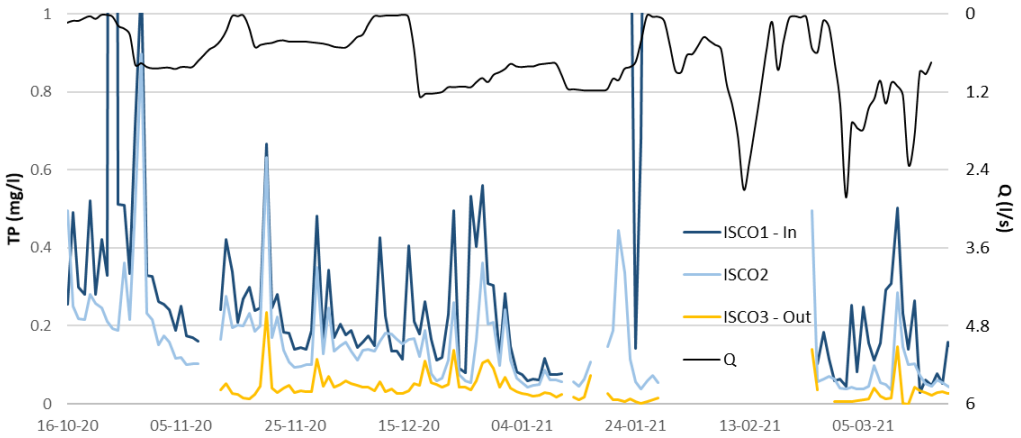

Figure 6 Daily values of total phosphorus (TP) at the inlet (ISCO1), between the sediment and reactive filter (ISCO2) and at the outlet (ISCO3) of the filter system. The hydraulic loading (Q) is given on the secondary axis.

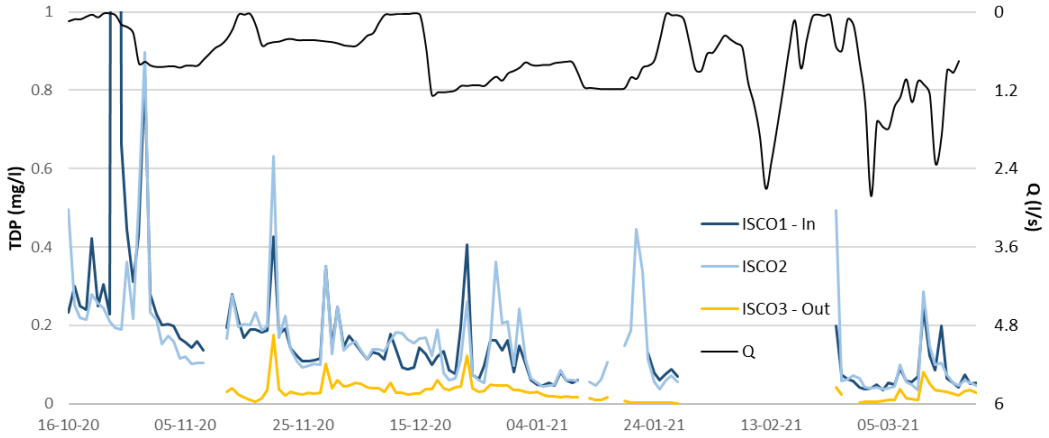

Figure 7 Daily values of total dissolved phosphorus (TDP) at the inlet (ISCO1), between the sediment and reactive filter (ISCO2) and at the outlet (ISCO3) of the filter system. The hydraulic loading (Q) is given on the secondary axis.

The hydraulic loading (Q) to the filter system during the 2020-2021 season reached 2.82 l/s. Higher peaks were recorded from February 2020 and their reduction generally occurred in the 2-5 days following isolated rain events.
Total P concentrations in drainage water at the inlet (ISCO1) varied between 0.03 and 2.47 mg TP/l, while TDP varied between 0.04 and 0.84 mg/l. Values of TP at the outlet (ISCO3) ranged from 0.00 to 0.36 mg/l, while TDP ranged from 0.00 to 0.32 mg/l. The three highest peaks in October and January were due to partial remobilization of P during cleaning operations of the filter system. The missing data in February 2021 are due to very low temperatures and consequent system freezing.
Average monthly retention of TP for the overall system varied between 73 and 83%. The positive retention efficiency was primarily attributed to the TDP retention by the ICS, which varied between 60 and 79%.

Financial aspect

Investment and operational costs of commercial systems are currently difficult to estimate as filter systems are under development. An operational filter system does not require a large use of sensors and flowmeters for continuous monitoring. Operational costs are site-specific and associated with risk of clogging and limited P sorption capacity of the reactive material.

Conclusion

The results from the first drainage season indicate that the filter system provides good TP and TDP removal efficiency. A detailed analysis indicates that both the sediment and reactive filter were capable of removing most of the particulate-bound and reactive P during the monitoring period.
The monitoring program will continue to study the interactions of the removal pathways of particulate P in a long-term operation mode.