Interreg
North Sea Region
NuReDrain
European Regional Development Fund

EUROPEAN UNION

FILTER SYSTEMS FOR A SUSTAINABLE AGRICULTURE

FIELD CASE DESCRIPTION

Phosphorus filter box for drainage water

GHENT UNIVERSITY

Location

Country: Belgium
City: Zedelgem
Coordinates: 51,131637 - 3,137576

Figure 1 Driving route to site Zedelgem

Problem description

P concentrations in the drainage water are too high (on average 0.2 mg/L) to meet the EU standard in the receiving surface water. The basic concept to reduce these P losses is installing a filter box containing a P sorbing material (PSM) at the end of the drainage tubes. This forces the water through the filter material and allows the removal of P from it before entering the ditch (Figure 2).

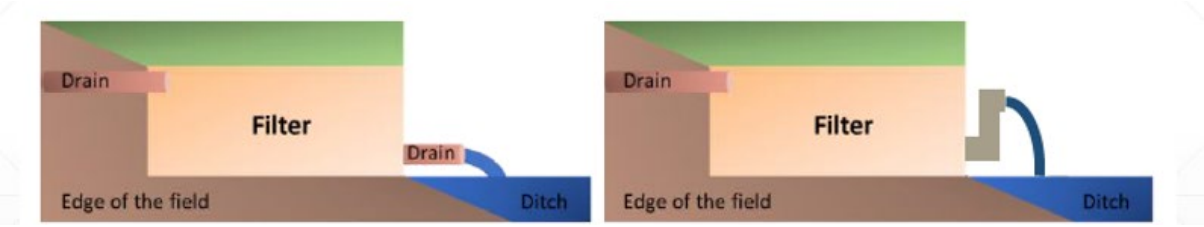

Figure 2. Schematic overview of the installation of P filters in the field

Filter description

Season of 2017-2018

Two custom-made bucket filters (100 L, Figure 3) were filled with iron coated sand (marked as **ICS_Ton** in Figure 6) and Diapure (marked as **Diapure_Ton** in Figure 6). Filter materials were filled a layer of no more than 20 cm, approximately 32 L. Two layers of wire mesh of 0.75mm were placed at the bottom and top of filter materials to stop big particles. The height difference between inlet and outlet tube was 5 cm.

Season of 2018-2019

Two filters installed from 2017 were kept in the field and the filter materials, i.e. ICS and Diapure were replaced with fresh ones. One prototype filter from CGK (600 mm*480 mm*590 mm, Figure 4) was installed in winter 2018 with 40 L of ICS (no more than 20 cm). This filter was marked as **ICS_Prototype_2018** in Figure 7.

Season of 2019-2020

The rectangle prototype filter from 2018 stayed in the field to check the long-term performance of the filter. Two new prototype filters (cylindric shape, Figure 5) were installed in Dec 2019 with different particle size materials (ICS>2mm and ICS>1mm marked as **Prototype_ICS>2mm** and **Prototype_ICS>1mm** in Figure 8, respectively). A layer of 24 cm with approximately 35 L of ICS was filled in the filters.

Season of 2020-2021

One prototype filter from 2018 and two from 2019 stayed in the field to check the long-term performance of the filters.

Photos filter

Figure 3 custom-made filters in the season of 2017-2018

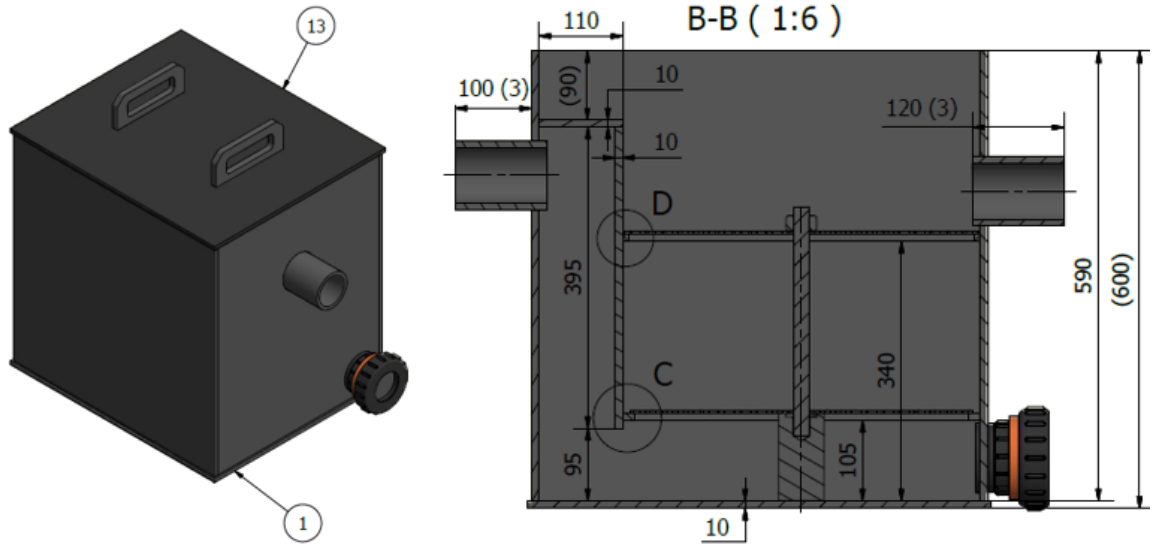

Figure 4 Prototype installed in the season of 2018-2019

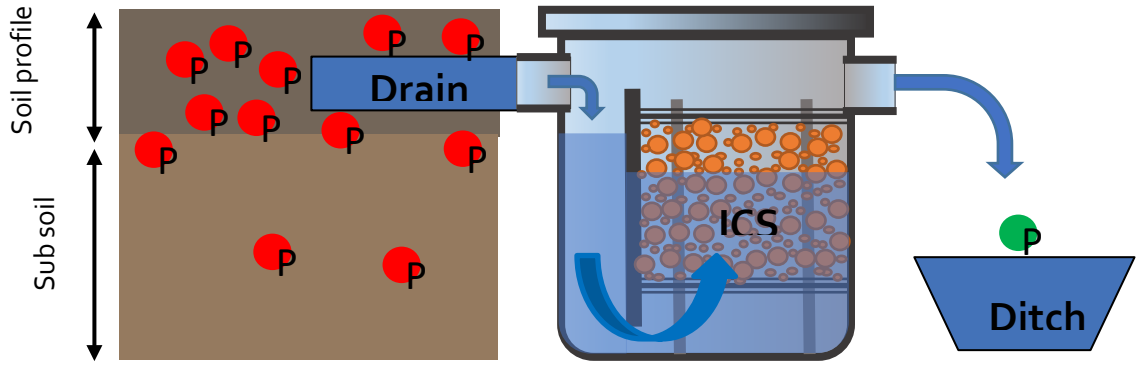

Figure 5 Prototype installed in the season of 2019-2021

Results (through the different seasons)

Season of 2017-2018

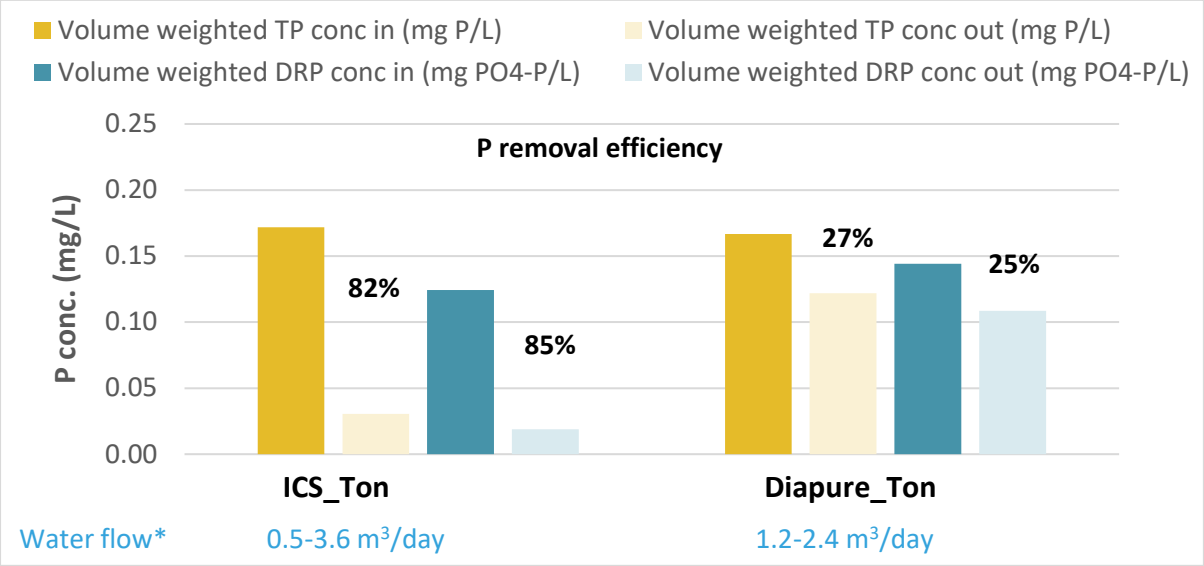

Figure 6 P removal efficiency of ICS_Ton and Diapure_Ton during the season of 2017-2018.

*water flow was measured every week and this range represented the water flow on the measuring days.

Two custom-made filters with different filter materials showed different P removal efficiency: 82% of total phosphorus (TP) and 85% of dissolved reactive phosphorus (DRP) was removed by **ICS_Ton** during the period of 9/10/2017 - 17/4/2018, while 27% of TP and 25% of DRP was removed by **Diapure_Ton** during the period of 16/1/2018 - 17/4/2018. Diapure_Ton was reported with clogging and frost problem on 22/1/2018.

Season of 2018-2019

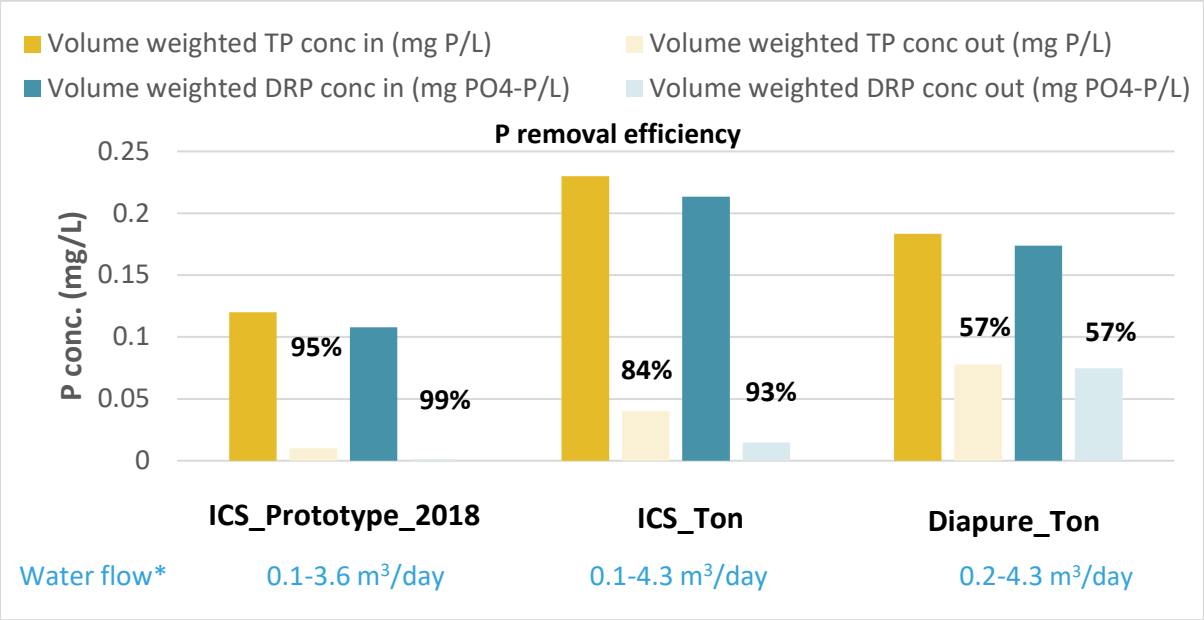

Figure 7 P removal efficiency of ICS_Prototype_2018, ICS_Ton and Diapure_Ton during the season of 2018-2019.

*water flow was measured every week and this range represented the water flow on the measuring days.

The performance of two custom-made filters and one prototype filter was evaluated in this season. On average, 84% of TP and 93% of DRP was removed in ICS_Ton during the period of 19/12/2018 – 5/4/2019 while 57% of TP and 57% of DRP was removed during the same period in Diapure_Ton. The performance of the prototype filter was more robust compared with the custom-made filters as most of the P was removed by ICS_Prototype_2018, although the lower P level and smaller water flow should be taken into account.

Season of 2019-2020

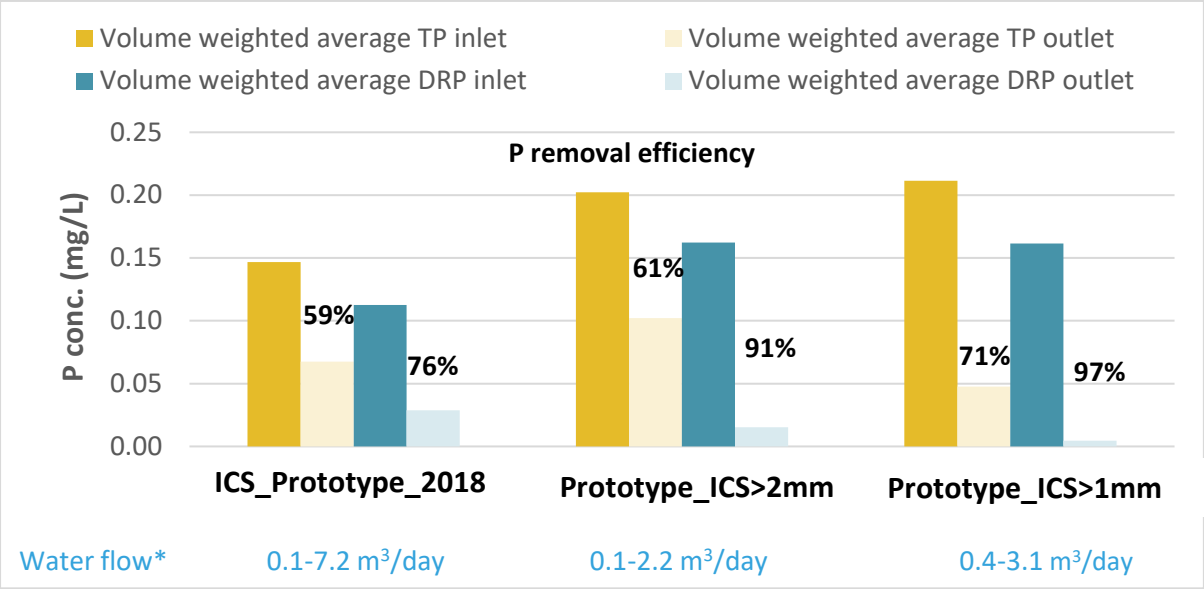

Figure 8. P removal efficiency of ICS_Prototype_2018, ICS_Ton and Diapure_Ton during the season of 2018-2019.

*water flow was measured every week and this range represented the water flow on the measuring days.

The filter performance of three prototypes was evaluated during this season to check the long-term performance of **ICS_Prototype_2018** and the effect of the ICS particle size. In the second drainage season of ICS_Prototype_2018, 59% of TP and 76% of DRP was removed even at the low P level during the period of 10/1/2020 – 23/3/2020. The long-term performance of the filter is better than we expected and the field monitoring in the following drain season would continue to see when the filter materials get saturated. Different particle sizes of filter materials were used in filters. As we expected, filter with smaller particles of ICS (**Prototype_ICS>1mm**) showed higher P removal efficiency, 97% of DRP and 71% of TP than one with bigger particles (**Prototype_ICS>2mm**, 91% of DRP and 61% TP) due to the longer reaction time.

Season of 2020-2021

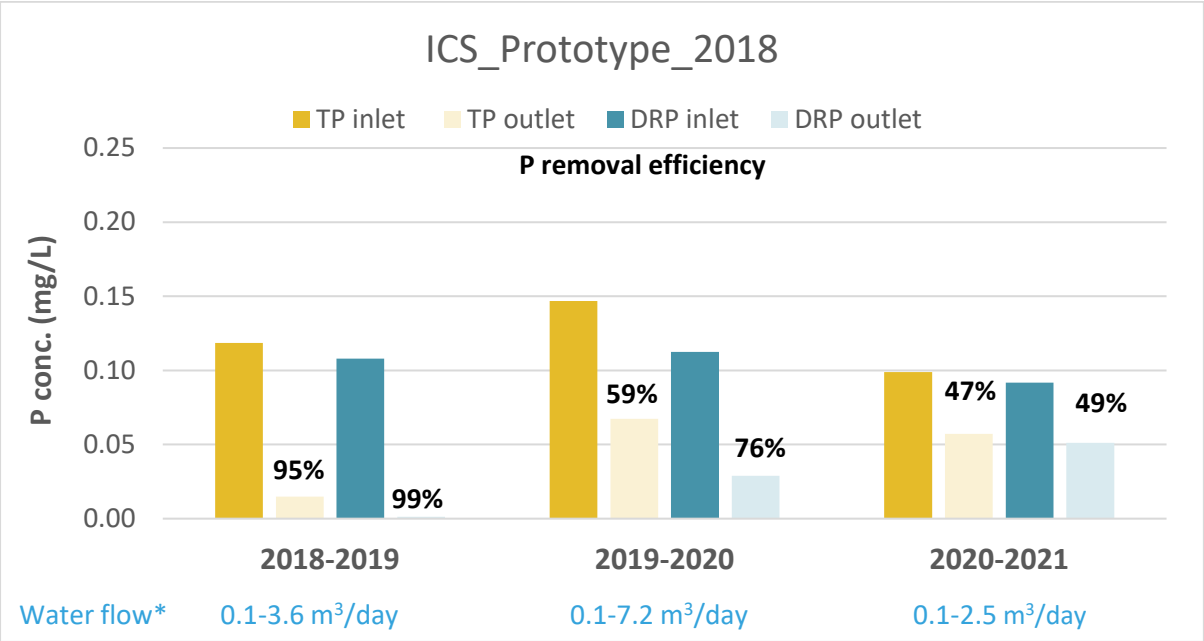

Figure 9. Long-term performance of ICS_Prototype_2018 over three drainage seasons

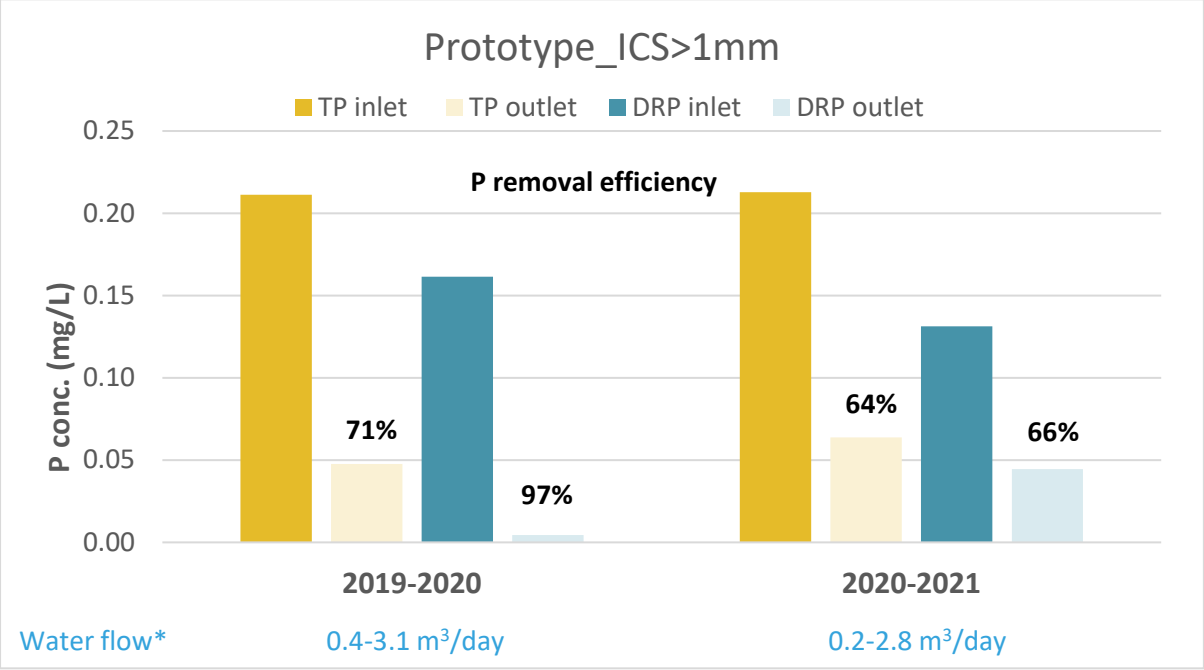

Figure 10. Long-term performance of Prototype_ICS>1mm over two drainage seasons

*water flow was measured every week and this range represented the water flow on the measuring days.

After three drainage seasons, the P removal efficiency of **ICS_Prototype_2018** decreased gradually: on average 94%, 59% and 47% of total P (TP) meanwhile 99%, 76%, 49% of dissolve reactive P (DRP) was removed in the first, second and third season, respectively (Figure 9). Two different particle sizes of filter materials were used to check filter performance since winter 2019. The filter with fine filter materials, **Prototype_ICS>1mm**, could remove on average 71% and 64% of TP meanwhile 97% and 66% of DRP in the first and second season, respectively (Figure 10). Unfortunately, we could not take samples properly in the second season from the filter with coarse particles, **Prototype_ICS>2mm**, because either the outlet tube was under water level of the ditch or the drainage water was limited. In the first season, we observed a better performance of filter with fine particles due to the longer reaction time, however, we could not make comparison in the second season.

Conclusion

During the seasons of 2017-2018 and 2018-2019, ICS as filter material showed a much higher P removal efficiency than Diapure, therefore only ICS was selected as filter material after 2019. In the season of 2018-2019, most of P (95% of TP and 99% of DRP) was removed by the prototype filter box which performed better than the custom-made bucket. In the season of 2019-2020, ICS with finer particles was observed with higher P removal efficiency due to the long reaction time. After three drainage seasons, the prototype filter with ICS could still remove more than half of the P from the drainage water though the efficiency gradually decreased over time. Further monitoring would be needed to see when ICS get saturated.