P filterbox for drainage water

Location

Country: Belgium
City: Staden
Coordinates: 50.95666, 3.01749 (Staden_Groot)
50.956871, 3.022005 (Dig-in_ Staden_1)
50.958803, 3.019446 (Dig-in_ Staden_2)

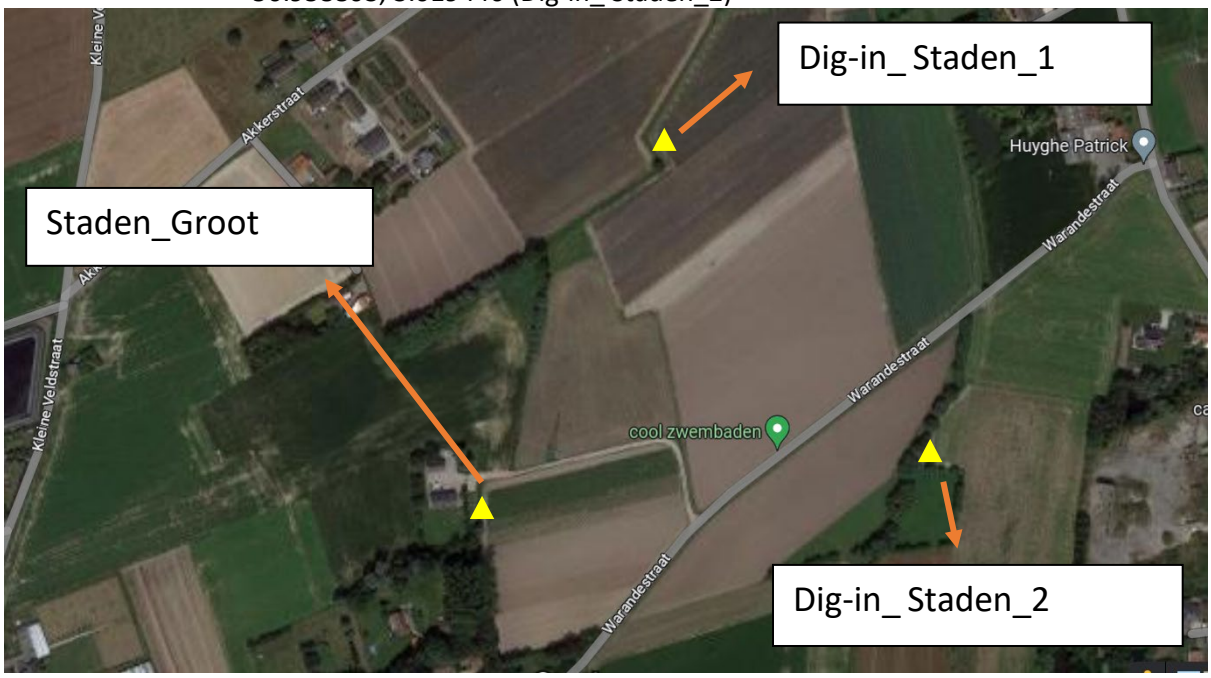


Figure 1. three sites at Staden

Problem description

P concentrations in the drainage water are too high (on average 0.46 mg TP/L and 0.38 mg DRP/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). Ideally, the P filter box should not be placed in the ditch as the ditch should not be obstructed.

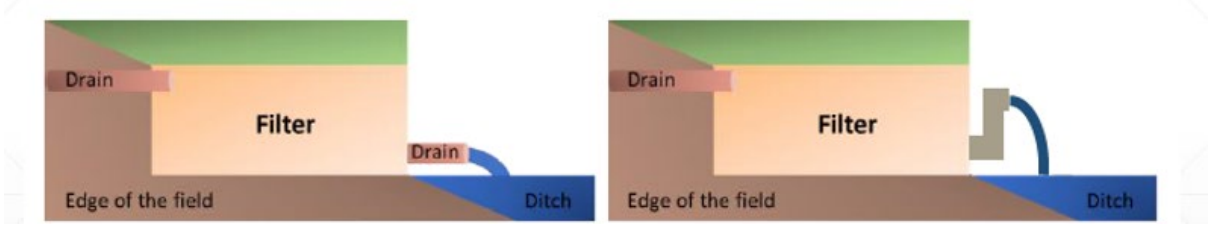


Figure 2. Schematic overview of the installation of P filters in the field

Filter description

Site: Staden_Groot

Season of 2017-2018 (The custom-made filter)

One rectangular filter box was installed in January 2018 (Figure 3) filled with iron coated sand (ICS). Filter materials were filled with a layer of no more than 20 cm (approximately 32 l). A layer of wire mesh of 0.75 mm was placed on the bottom to stop big particles. Water enters the filter directly from the top of box and the height difference between outlet tube and the top was 5 cm.

Season of 2018-2019 (The custom-made filter with renewed ICS)

The same filter box was used but the ICS was removed as there was a lot of sediment/soil/algae in the filter. The filter box was cleaned and then refilled with fresh sieved ICS.

Season of 2019-2020 (Prototype filter)

The new prototype filter (cylindric shape, Figure 4) was installed in December 2019 with sieved filter materials (ICS>2mm). A layer of 24 cm being approximately 35 l of ICS was filled in the filters.

Season of 2021-2022 and 2022-2023 (Larger prototype filter)

The prototype from season 2019-2020 was kept until January 2021. Then a bigger filter was installed on 2 February 2021 and filled with a layer of 24 cm, approximately 120 l, of ICS >2mm (Figure 5). The water in Staden was drained from a larger field (1-2 ha) which was beyond the processing capability of the small filter. Therefore, a bigger filter was designed and installed to check if P removal efficiency could be improved.

Site: Dig-in_Staden_1 and Dig-in_Staden_2

Season of 2020-2021 and 2021-2022 (Dig-in prototype filter)

Two prototype filters were installed by burying the filter boxes at the edge of two different fields to avoid disturbing the waterway. These filters were tested for two drainage seasons (Fig 6). These filters contain a vertical tube for collecting water samples before passing through the filters. The installation is more complex than just placing the filter in the ditch and connecting to the drainage pipes, while it has been proven feasible with a small crane.

Photo filter

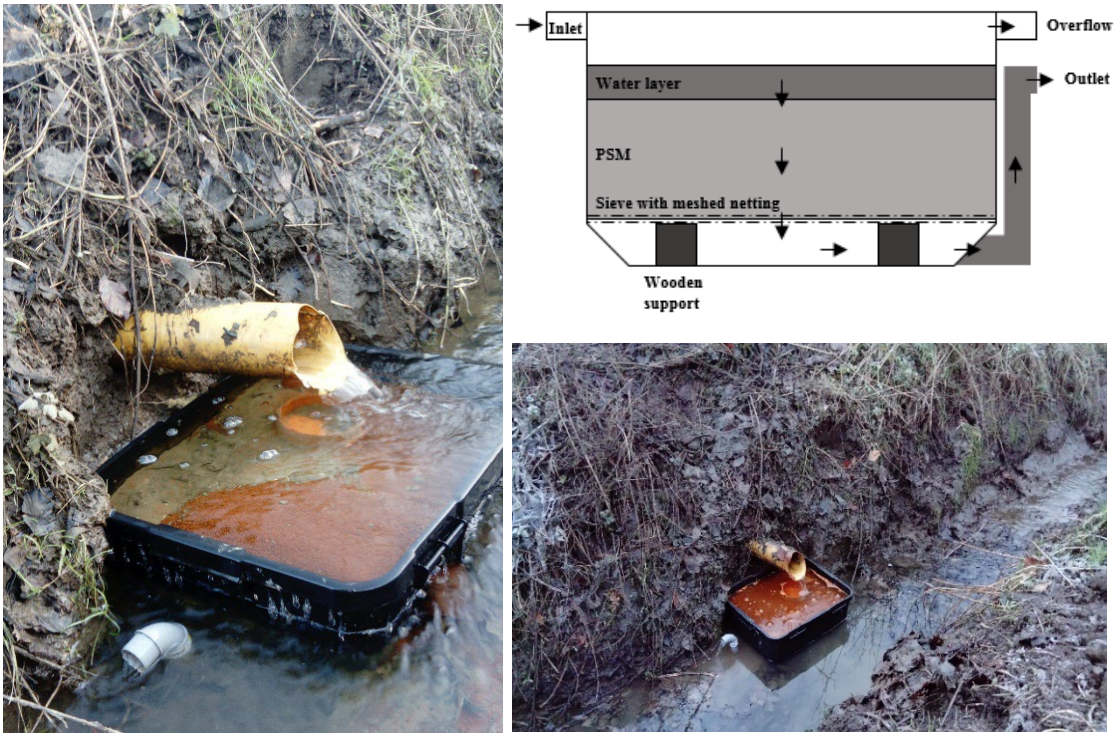


Figure 3. the custom-made filter in the season of 2017-2018

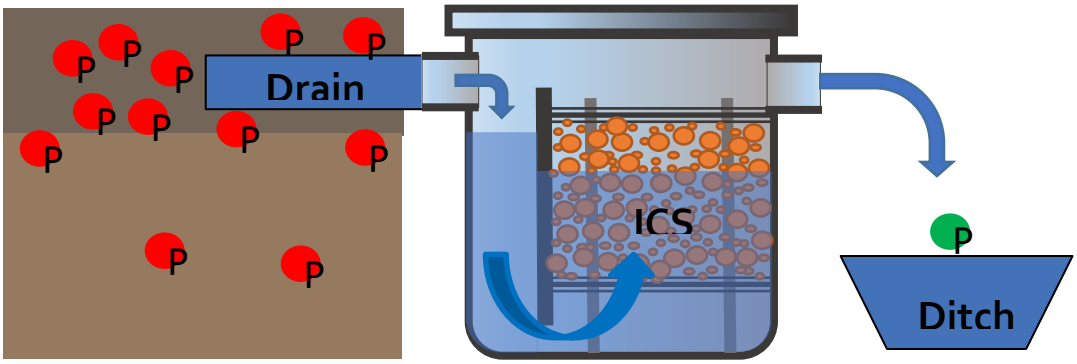
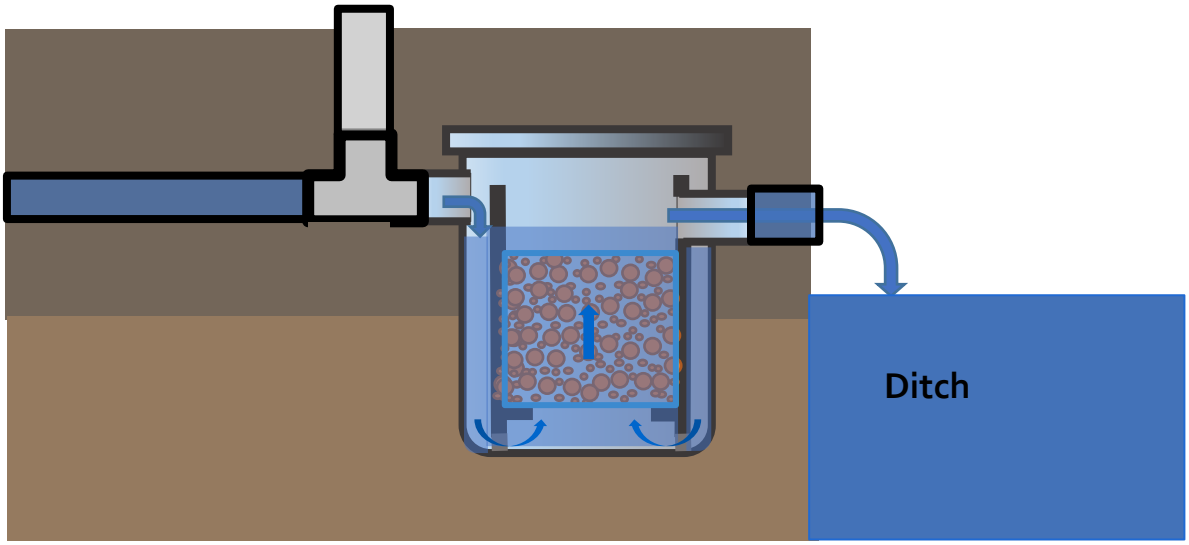


Figure 4. Prototype installed in the season of 2019-2020

Figure 5. Larger prototype filter installed in February 2021



Dig-in_ Staden_1

Dig-in_ Staden_2

Figure 6. Dig-in filters installed in Jan 2021

Results (through the different seasons)

Site: Staden_Groot

Season of 2017-2018 (Custom-made filter)

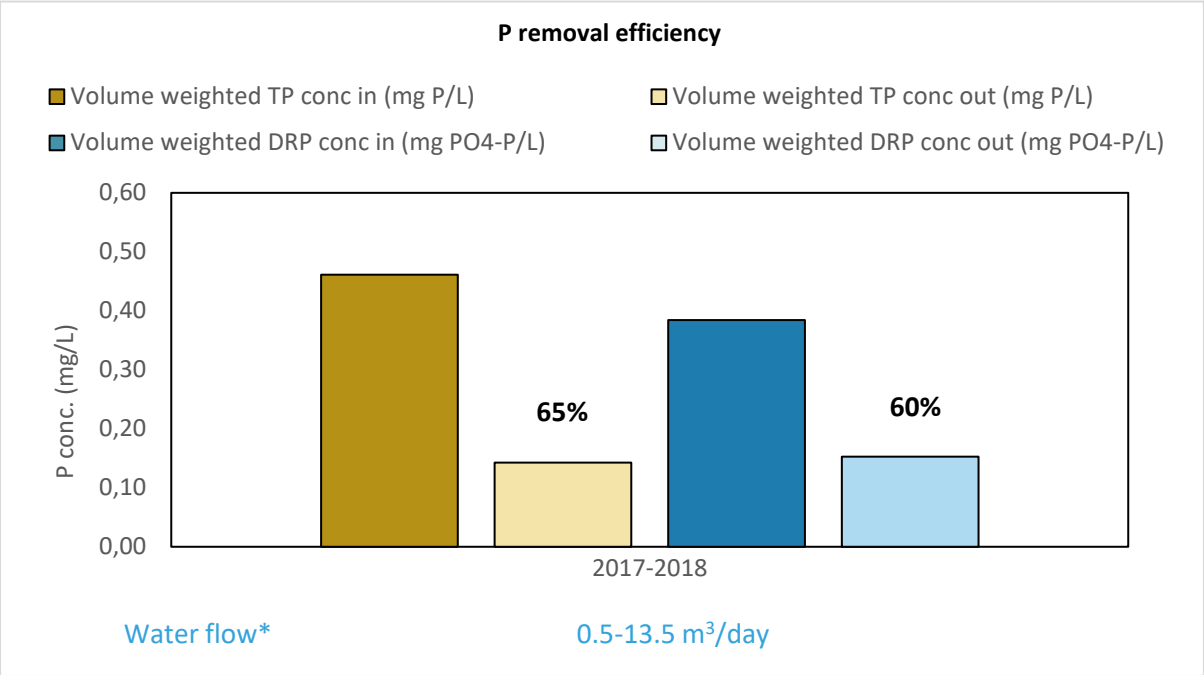


Figure 7. P removal efficiency of custom-made filter box during the season of 2017-2018.

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

In the site of Staden_Groot, 65% of total phosphorus (TP) and 60% of dissolved reactive phosphorus (DRP) was removed by the custom-made filter during the period of 9/1/2018 - 11/4/2018 with an average water flow of 5 m^3/day. Frost problems occurred during the period of 21/2/2018 - 28/2/2018.

Season of 2018-2019 (Custom-made filter with renewed ICS)

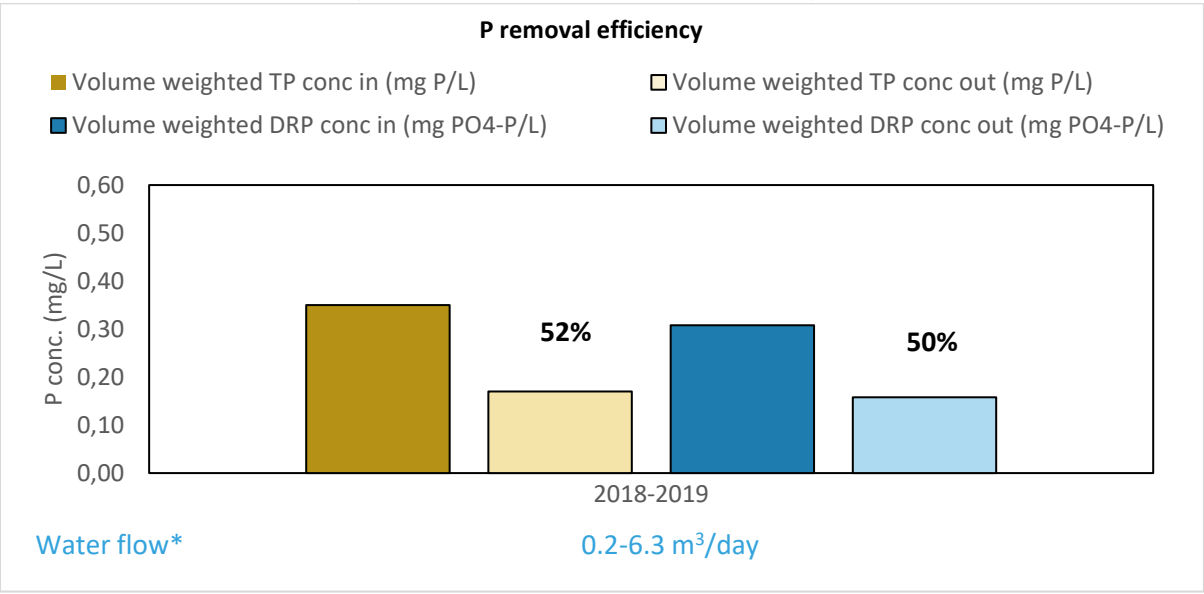


Figure 8. P removal efficiency of custom-made filter box during the season of 2018-2019.

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

At the site of Staden_Groot, 52% of TP and 50% of DRP was removed by the custom-made filter during the period of 20/12/2018 - 28/3/2019 with an average water flow of 2.3 m^3/day. Overflow happened on the dates of 31/1, 8/2, 8/3, 15/3/2019 and a white foam was observed in the drainage tube on 8/2/2019.

Season of 2019-2020 (Prototype filter)

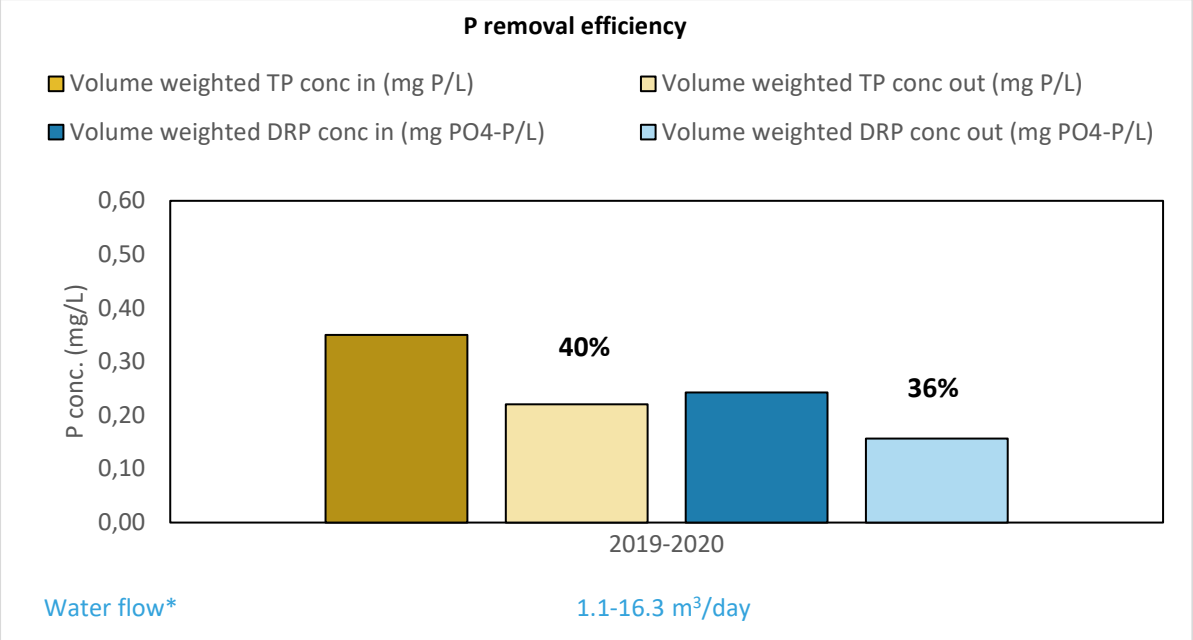


Figure 9. P removal efficiency of prototype filter during the season of 2019-2020.

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

At the site of Staden_Groot, 40% of TP and 36% of DRP was removed by prototype filter during the period of 9/1/2020 – 13/3/2020 with an average water flow of 6.36 m^3/day. It was reported with overflow on the dates of 10/2, 14/2 and 3/3/2020.

Season of 2021-2022 and 2022-2023 (Larger Prototype filter)

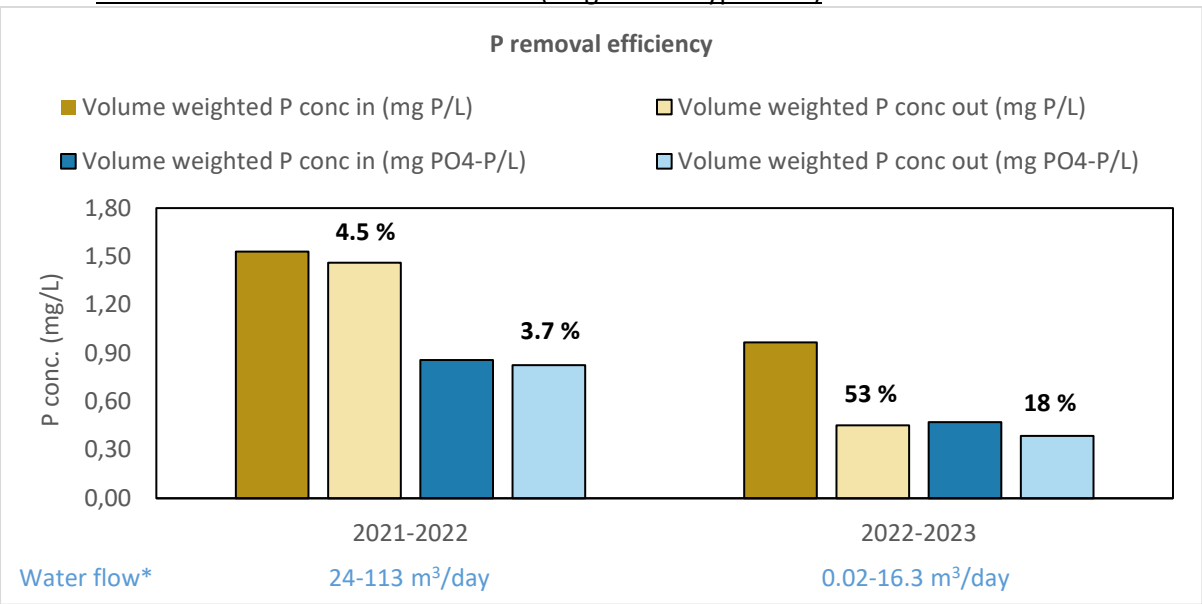


Figure 10. P removal efficiency of prototype filter during the season of 2019-2020.

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

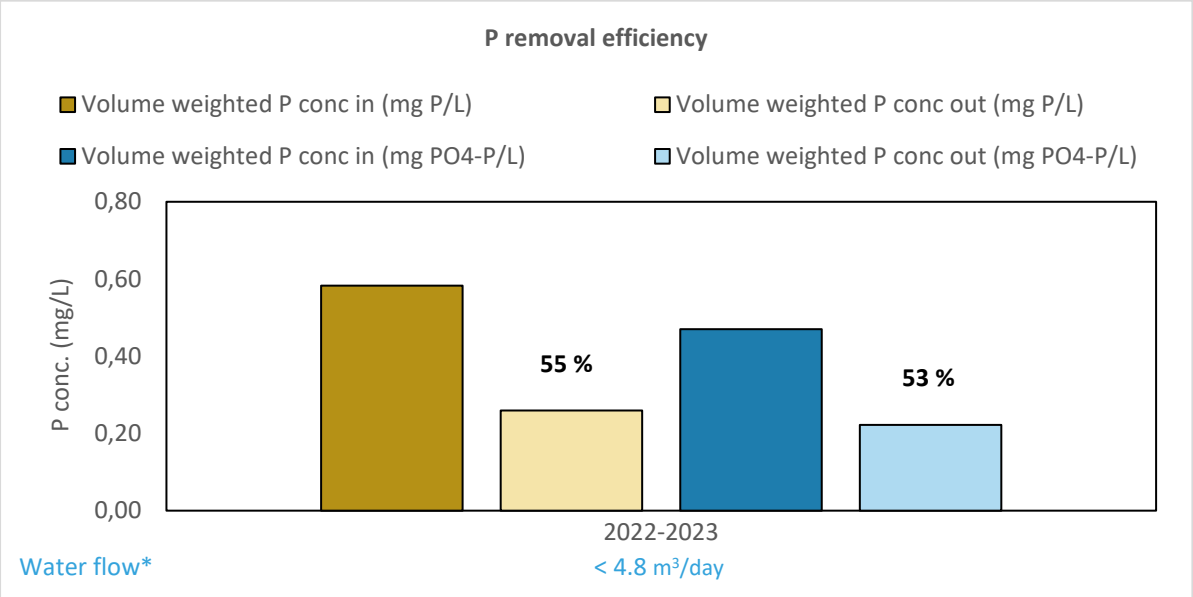


Figure 11. P removal efficiency of the larger prototype filter during the season of 2022-2023 with the flow rate below 4.8 m^3/day.

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

At the site of Staden_Groot, the prototype during drainage season 2019-2020 showed low P removal efficiency (40-65% of TP and 36-60% of DRP) compared to site Zedelgem due to the large water flow. However, this larger prototype filter with 120L ICS did not show better performance with the high flow rate, which probably due to overflow. Still, with the flow below 4.8 m^3/d, the filter showed better performance (55 % of TP and 53 % of DRP)

Site: Dig-in_Staden_1

Season of 2021-2022 and 2022-2023 (Dig-in prototype filter)

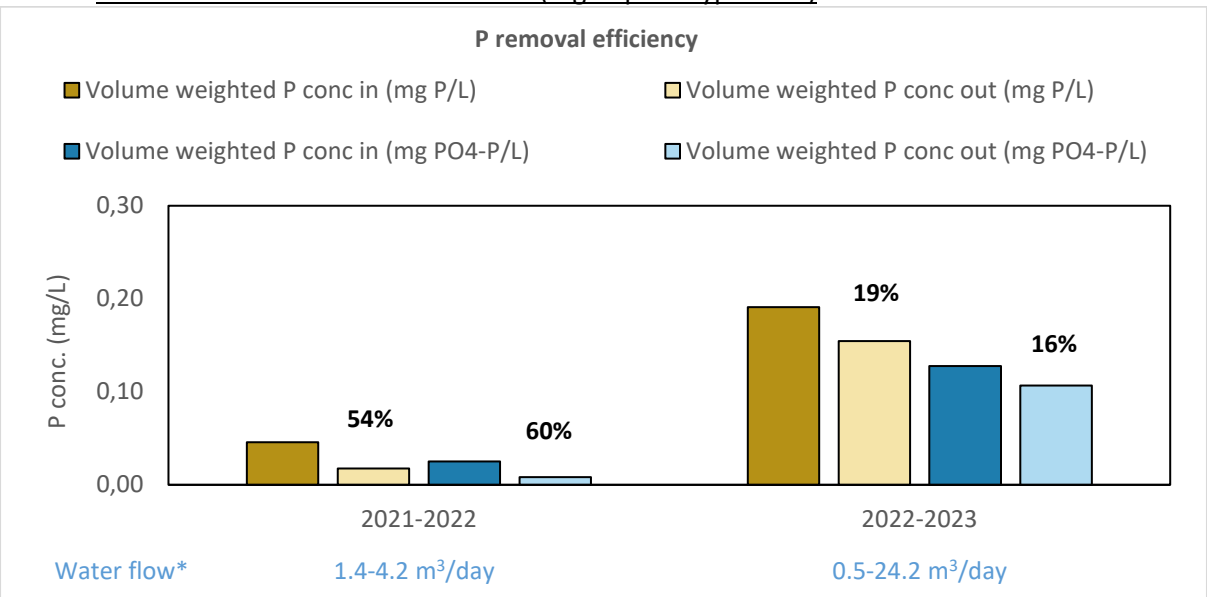


Figure 12. P removal efficiency of Dig-in_Staden_1 during the two seasons.
**water flow was measured every week and this range represented the water flow on the measuring days.*

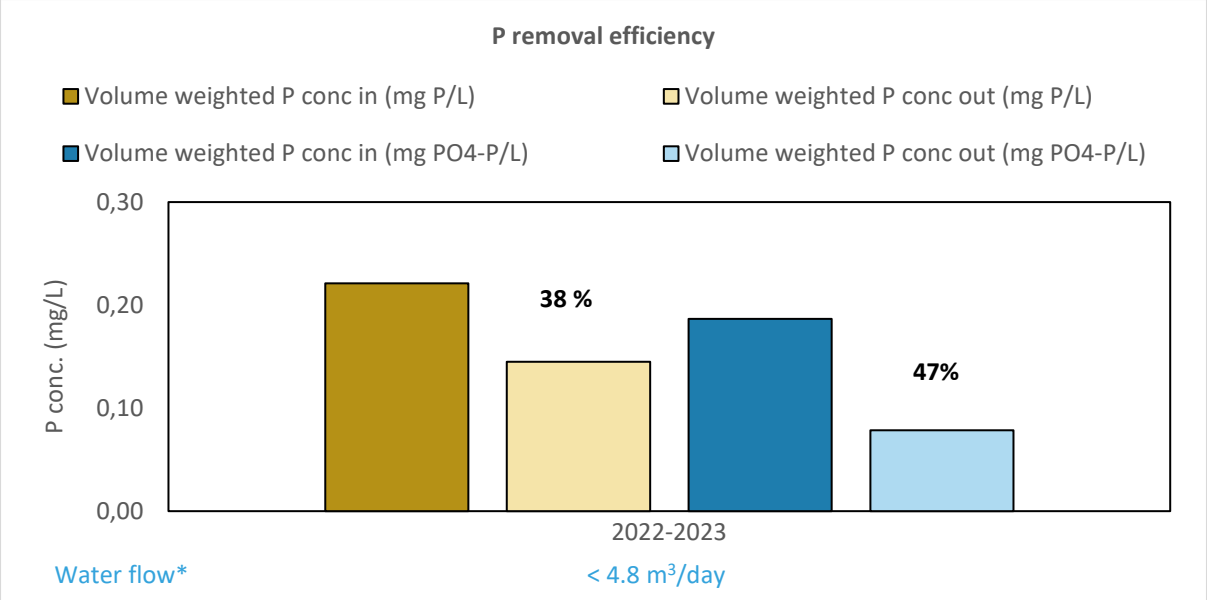


Figure 13. P removal efficiency of Dig-in_Staden_1 during season 2022-2023 with flow rates below 4.8m³/d.
**water flow was measured every week and this range represented the water flow on the measuring days.*

Site: Dig-in_Staden_2

Season of 2021-2022 and 2022-2023 (Dig-in prototype filter)

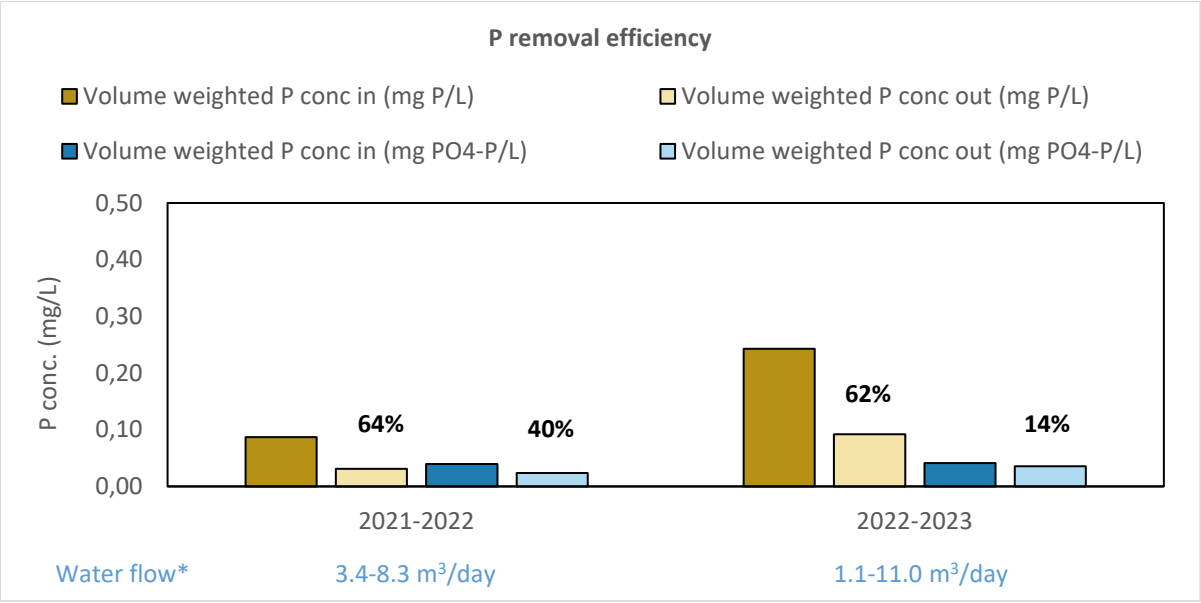


Figure 14. P removal efficiency of Site: Dig-in_Staden_2 during two seasons.
**water flow was measured every week and this range represented the water flow on the measuring days.*

For the dig in filters, the drainage water showed low P concentration in the first drainage season. During the second drainage season, Dig-in_ Staden_1 showed P removal efficiency of 55 % for TP and 53 % for DRP when flow rate lower than 4.8 m^3/day. At the site of Dig-in_ Staden_2, DRP remain lower than 0.1 ppm during the drainage season 2022-2023, while Dig-in_ Staden_2 reduced TP by 62%.

Conclusion

During the five drainage seasons, different filter boxes filled with fresh ICS showed P removal efficiency varied from 40-65% of TP and 36-60% of DRP while the long-term performance of ICS reduced evidently to 36% of TP and 15% DRP. The P removal efficiency was rather low compared with filters in Zedelgem due to the larger water flow beyond the designed processing capacity (6-8 m^3/day), therefore a bigger prototype with was installed in Febrary 2021. Unfortunately, the larger prototype still cannot handle the larger and extreme flow at the site of Staden_Groot. Further monitoring of the bigger filter will be continued in season of 2023-2024. The dig-in filter was proven to be a feasible solution to avoid placing the filter in the ditch, and showing good performance within its capacity.