P filters - Drain water from horticulture

Location 1

Country: Belgium
City: Destelbergen
Coordinates: N 51,07039 - E 3,81565 (PCS)

Location 2

Country: Belgium
City: Nevele
Coordinates: N 51.03476 - E 3.52911 (Floristry Meuninck)

Location 3

Country: Belgium
City: Zaffelare
Coordinates: N 51.12407- E 3.85402 (VDS Plant)

Location 4

Country: Belgium
City: Lochristi
Coordinates: N 51.08085- E 3.82130 (Microflor)

Location 5

Country: Belgium
City: Oosteeklo
Coordinates: N 51.19255 - E 3.72398 (Filip Willems)

Problem description

Applying chemical fertilizers to soil already saturated with phosphates and spreading excessive amounts of manure on land causes phosphates to run off during heavy rainfall and pollute nearby water sources. Greenhouses reuse their drain water as much as possible, but 5-10% of the water that can't be reused can contain high amounts of P. When the amount of total phosphorous exceeds 100 parts per billion (ppb) in streams or 50 ppb in lakes, eutrophication -- the effect of algal blooms -- is a danger. Phosphorus removal from wastewater can be achieved by the adsorption to filter materials.

Filter description

Iron rich waste products of drinking water companies can be used as filter material for P removal. During the production of drinking water, the companies use biological and adsorptive deferrization because groundwater often contains high iron concentrations (> 15 mg/l). In addition to biologically formed sludge, there is also iron deposition on sand grains. In this fast sand filtration process, ICS (= Iron Coated Sand) is formed by the adsorption of iron on the sand cores. Due to the deposition of iron on the grain surface, the iron grain grows steadily and part of the grain must be removed from the sand bed periodically. It is this adsorbed filter material (ICS) that can be used for another adsorption processes including the removal of phosphate from water (Photo 1).

With iron removal from groundwater, solid iron sludge can also be formed. When this sludge is pelletized, the phosphate removal can take place via the same process (Photo 1).

At location 1 (PCS), 6 types of filter materials to remove P were compared (Photo 2):

ICS and pellets

In 2017, 2 IBC containers of 1 m^3 each were filled up to 80% with these filter materials. Phosphorus is removed by binding to iron oxide of the filter material. Each filter processes an average of 0.8 m^3 of wastewater per day. However, the pellets were saturated in 2021 (so after 5 years) and this filter was switched off due to a lack of new material.

VITO A and VITO B – started in 2021

Project partner VITO uses sludge from a drinking water production plant for the production of 2 phosphate absorbents based on iron and aluminum oxide. VITO A is material based on aluminum oxide, VITO B is material based on iron oxide.
The 70L drum was filled with 50L VITO A and processed approximately 50L per day, while the 10L drum was filled with 7L VITO B and processed approximately 7L per day.
On 11/08/22 the capacity of this filter was adjusted. From then on, VITO A processed 100 liters per day and VITO B processed 14.4 liters per day. By switching off the P-filter with pellets on 6/09/2022, insufficient water was processed by the remaining P-filter and there was now a lot of water in the well after the reed bed. The working hours of VITO A and B were doubled again and each processed 200 and 28 liters per day, respectively. This turned out to be too high.

ICS from UGent – started in 2022

UGent uses ICS granules to remove phosphorus from drainage water from agricultural plots. This often involves very low P concentrations, which means that the granules for this application can quickly become saturated. In 2022, it was investigated whether these granules can still be used in floriculture, where the P levels in the wastewater are higher than in drainage water. The set-up is comparable to VITO's aluminum-based material, a 70L drum was filled with 50L material.

Regenerated ICS – started in 2022

The next step to further improve the filters is the reuse of saturated filter material. As such, nutrient removal will become even more sustainable and contribute to the circular economy. VITO researchers have successfully examined the possibilities of separating the 'trapped' phosphates from the granules without damaging the structure of the granules. These regenerated grains have also been tested at the PCS on a pilot scale since the summer of 2022. The set-up is comparable to VITO's iron-based material, a 10L drum was filled with 7L of material.

	
Iron Coated Sand granules (ICS)	Pellets made from iron-ridge sludge

	
VITO A	VITO B
	
Regenerated Iron Coated Sand granules	Iron Coated Sand granules from UGent

Photo 1: 6 filter material tested to remove P from wastewater at PCS

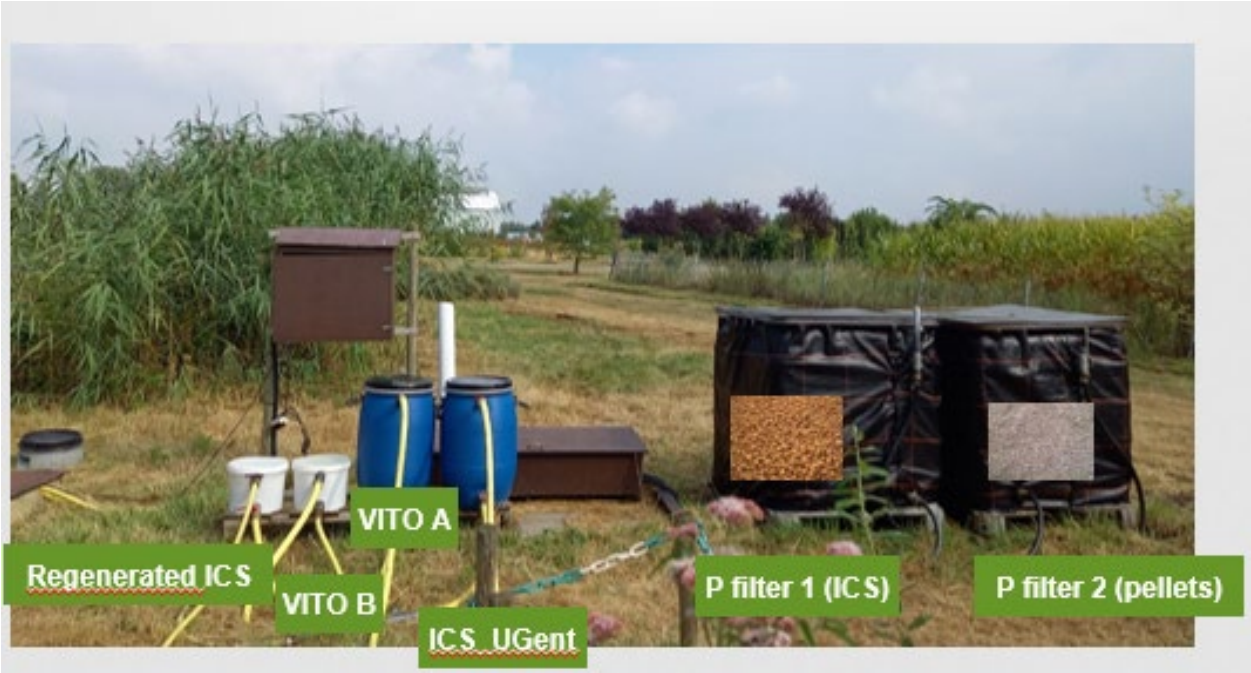

Photo 2: P filters at PCS (in parallel)

Floristry Meuninck

At Floristry Meuninck, already for several years, all drain water is collected in a storage tank during winter, and in spring/summer, water is pumped through P filters. In 2019, also a MBBR filter was placed at Floristry Meuninck (Photo 3).

Initially, the water from the water silo flowed first through the MBBR and then went through 2 phosphor filters but, due to clogging problems in the phosphor filters, it was decided to reverse the order. This clogging was probably due to biofilm that developed in the MBBR and was carried along to the P filters. During the winter of 2021-2022, the system was modified so that the water goes through the 2 phosphorus filters first and then through the MBBR. It was also observed that the ICS granules in the phosphorus filters were saturated; these were also replaced in early 2022.

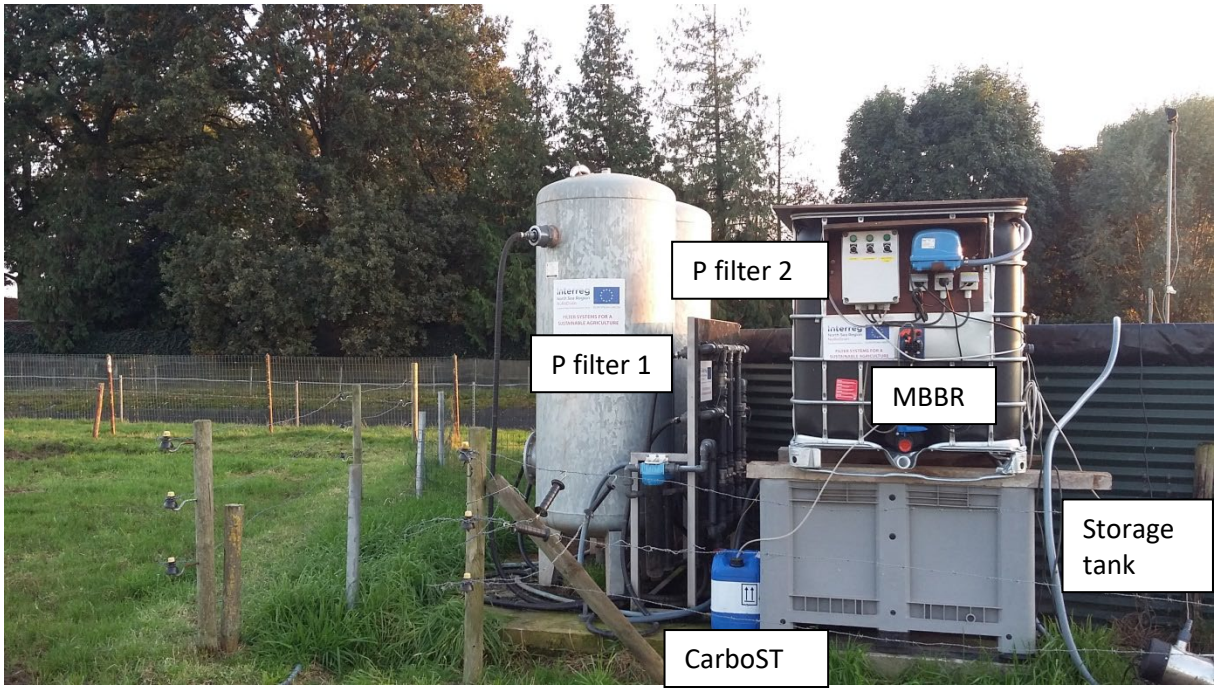

Photo 3: MBBR and P filters at Floristry Meuninck

VDS-Plant

In early July 2022, a 2-in-1 do-it-yourself filtration system was installed at VDS Plant. The first IBC is filled with ICS granules for P removal, the second IBC is a Moving Bed Bioreactor (MBBR) responsible for N removal (Photo 4). These filtration systems process the effluent from an azalea greenhouse. The water is collected in an underground citern and then flows from bottom to top through the P-filter and then by gravitation to the MBBR. Daily, the filters process 1.5 m^3, but can handle up to 3 m^3 if necessary.

Photo 4: 2-in-1 N and P do-it-yourself filtersystems at VDS Plant

Microflor

In mid-November 2022, a 2-in-1 N and P do-it-yourself filter was installed at the company Microflor (Photo 5), a young plant company of mainly orchid and Helleborus. All effluent produced at this farm is collected in a silo. This contains the backwash water from backwashing the multimedia filter and residual water from drain wells. Per day 760 l is processed (pump running every hour for 1 min) from this silo at the request of the company. The actual capacity is higher, namely 3000l (3 m^3). CarboST is added as carbon-source. Care is taken to ensure that the system cannot freeze in winter, because this company also has effluent in winter.

During the first winter, nevertheless, the filter was down for a while. Microflor also has a constructed wetland that must be adequately fed with a continuous flow, and so, the treated water of our filter system, was sent back into the large citern. But due to an increase in the COD value, it seemed better to drain the effluent from our filters into the first aerated constructed wetland instead of into the collector silo.

Photo 5: 2-in-1 N and P do-it-yourself filtersystems at Microflor

Filip Willems

In spring 2023, a subsequent 2-in-1 N and P do-it-yourself filter was installed on Filip Willems' azalea farm (Photo 6). This farm consists of 7.6 ha (greenhouses + covered fields). The drain water at this farm is captured; but it is not disinfected via a slow sand filter like at VDS-Plant, but via a high-pressure UV filter, just like at Microflor. In front of the buffer tank in which all drain water from inside and outside is collected, a sieve bend is installed as primary purification (= remove organic material). To ensure good transmission, a multimedia (= fast sand filter) is installed in front of the UV filter. At regular intervals, this rapid sand filter is backwashed. This backwash water is rich in nutrients and purified by the new 2-in-1 filter systems. The system was up and running since the summer of 2023.

Photo 6: 2-in-1 N and P do-it-yourself filtersystems at Filip Willems

Financial aspect

One cubitainer can handle 2 to 3 m^3/working day. If this volume is enough to filter all the water that a greenhouse can't re-use, thus has to be discharged, then the cost to build a P-filter is very low.
The installation cost of a 1-cubitainer P-filter is approximately € 690 and the operation cost is € 95. The yearly cost has been calculated and amount to € 164. The cost-effectiveness is € 85/ kg P. The cost of the ICS grains is almost € 1.000 for 700 kg of grains.

Conclusion

The P-filters show excellent performance, usually between 90 and 100% P removal. As long as the granules are not saturated, the effect is guaranteed. Even in winter, the effect is just as good, there is no temperature effect. When the grains have been at rest for some time, binding sites have again become available at the edges of the grains because the P can migrate deeper into the grains. ICS granules and pellets work just as well, but the pellets are no longer available because the drinking water company has a different market for its iron-rich sludge. Vito A and Vito B, 2 other materials, appear to be just as suitable as ICS. ICS granules that were first used in full field application to purify drainage water with a low P load can certainly be further saturated for greenhouse water when saturated in the field application. VITO has also succeeded in regenerating the saturated ICS granules with a strong base. These granules also worked very well in their second cycle. In this way, the circular story comes one step closer.

On 4 floriculture companies, Floristry Meuninck, VDS Plant, Microflor and at Filip Willems, 2-in-1 DIY systems were tested for the removal of N and P from greenhouse wastewater. In general, the systems on these farms work very well (at Filip Willems only just started up) and the same results are obtained as for the PCS-filters (90 to 100% P removal).