

QUESTIONS AND ANSWERS – NUREDRAIN FINAL CONFERENCE WEBINAR – 1 JUNE 2021

Q1: How often did you clean the P filterbox for particles?

A1: Filters were installed in the cropland of sandy soil. In our case, the filters were still in good status after one year of operation and the space at the bottom of the filter box seemed to be sufficient for the sediment. Only one out of five filters had clogging problem in the second year.

Q2: What is the DP/TP for the case study in Belgium?

A2: DP stands for dissolved phosphates while TP stands for total phosphorus including dissolved phosphates and particulate phosphorus. On average 90% of the TP are dissolved phosphates.

Q3: Has the iron content been measured in the water?

A3: We did not measure the iron content in the water samples. We did observe iron leaching right after installation but after a while (within one hour), the water became clear again. But this was the case for only one out of five filter boxes and in most cases, we did not see iron leaching. The water flow from individual drains was fluctuating with a maximum of 8 m³/day and with such low flow rates the iron coating was rather steady.

Q4: What is the impact of treating the spent material?

A4: To date only lab research has been done on the potential desorption of the P from the ICS filter material. An alkaline solution is needed to do so. However, a full LCA or LCC has not been done yet. The quantity of recovered P is too little to be economically viable. Desorption might however be interesting from the point of view of recycling the filter material. During NuReDrain, also other filter materials have been tested. Not only waste products (like ICS) but also products which are produced for this purpose (e.g. DiaPure, VITO-A and VITO-B material).

Q5: What happens with the filters (ICS+P) after use?

A5: To date, ICS is a waste product from the drinking water industry and is sold as construction materials provided that a specific permission from the environmental authority is obtained. It can also be used in the biogas sector to limit H₂S production. When ICS gets saturated upon P removal, we could recycle this material for civil engineering. However, then the P is lost. During the project, we found out that the P migrates to the core of the grain. When ICS gets saturated at low P concentration from agricultural drainage water, it could afterwards be used as filter material to remove P from greenhouse effluent.

Direct reuse of the saturated filter material as substrate for plants (and hence as a P fertilizer) was not successful. Alkaline desorption resulted in 40% P recovery from the filter material. The obtained quantity is however very low to be economically viable. One should further explore other valorization options (e.g. mono incineration of the saturated grains and P recovery from the ashes).

Q6: How many filters would be needed (per meter of stream or per ha of land)?

A6: It depends. After testing the filter boxes in different sites over several seasons, it was observed that P removal efficiency was much depending on the water flow rates and the P concentration. It should be estimated site specifically.

Q7: The durability of ICS is set to 2 years - does this mean the filtering capacity shown e.g. 0.12 inlet to 0.01 mg P/L effect continue for 2 years in the prototype?

A7: As I mentioned, the reason why we gave a range of cost estimation was due to the uncertainties. The durability of the filter material is very site specific. The filter efficiency is gradually decreasing but we observed that the filter could still remove about half of the phosphates in the third drainage season. We plan to monitor the long-term (even fourth or fifth year) performance of these filter boxes.

Q8: How do you explain the rather large differences in performance between the Flemish and the Danish system

A8: The large differences are caused by environmental factors (hydrological, hydrochemical and biogeochemical factors) which are depended on the catchment characteristics and by technical factors such as the filter design.

Q9: The stability of ICS in terms of loss of Fe to the water: did you monitor how much Fe was emitted to the water over the test period? - the question is relevant if one would apply the filter in oligotrof streams.

A9: Iron is released from the ICS during the first flushing at the beginning of the drainage season. This can be seen as a red discharge plume in the water. The filtered drainage water sample also has a higher iron content. This can interfere with the P measurement in the sample. A continuous measurement of the iron release has not yet taken place.

Q10: what is the mg P/g adsorbed in the first, second (and third) year in each experience? is there a threshold number where the efficiency decreases?

A10: It was difficult to make this estimation due to several reasons: 1) drainage seasons last differently each year; 2) P removal efficiency depends on water flow rate and inlet P content; 3) measurements were weekly rather than daily in Belgium sites. For the first year, we made the estimation based on the filter performance in Belgium and Denmark and it was in the range of 0.34–1.08 mg P/g ICS. For the second year, in Belgium trial the amount of P removed was similar to the first year. So far we did not see a threshold number. As our colleague from KU Leuven mentioned that the filter materials were saturated after two years. In fact, we observed that P sorption capacity of ICS recovered a bit during the off season. For filter materials Diapure, it was not possible to give an estimation due to clogging problems.

Q11: I suppose that the P in the German example is not really coming from agriculture but is mostly due to high anthropogenic P contents in the peat soil

A11: Agricultural used drained peat soils are often the largest P source in many catchments, since they can hardly store fertilized P and additionally P is released by peat decomposition. Therefore, the intensity of agricultural use on peat soils through the application of P fertilizers and the water management in these areas, that are often equipped with tile-drainage systems and ditches to keep the groundwater level low, are often causal for large P losses in those landscapes.

We attribute part of the high P content in the receiving water body to the drainage of the upstream (low) moorland sites. For the P content measured in the drainage pipe, we assume significant site-related influences, i.e. influences of the soil type, the type of crop cultivated, the fertilization practice, release and fixation processes in the soil.

Q12: What is your explanation of the big difference in removal efficiency, especially found by Kristine Bolte and Hui Xu?

A12: The drainage water in Germany is rich in amorphous organic matter (AOM) and the P present in the water is mainly particulate P. The effectiveness of the ICS-based P filter in Germany is reduced by clogging. There is no problem due to the input of mineral matter. AOM clogs the pore spaces and occupies the surface of the ICS. This leads to a backwater of water. The water runs off superficially or along preferential flow paths and is thus no longer filtered and the effectiveness decreases. In 2019/2020, the input of AOM was well filtered, the effectiveness was >80%. In 2020/2021, the input of AOM was very high, the effectiveness dropped to only >50%. At the same time, the proportion of dissolved P was higher (45% compared to 1.3% in 2019/2020). However, dissolved P cannot be retained in our filter. In contrast, P dissolved in the mobile filter boxes in Belgium can be retained well. There are also no problems with the input of mineral or organic substances.

Q13: How is the performance of these filterboxes / using ICS in water with higher salinity?

A13: The principle of P removal by ICS is binding phosphate onto iron rich materials. We believe this should still work for water with higher salinity though more tests should be carried out.

Q14: Could there also be differences in the ICS material (% of ferrihydrite)? Have you compared the materials from the 3 countries? or are they from the same origin?

A14: ICS materials from the different countries have not been compared. The ICS material used in Flanders was from a Flemish drinking water company while the material used in Germany was from a German drinking water company. It might be that the % ferrihydrite is (slightly) different.

Q15: did you check for GHG emission as a potential side effect?

A15: We are aware of the potential side effects of GHG emissions. Unfortunately, we were not able to measure the GHG emissions. We try to create optimal conditions to ensure a complete denitrification, for example by providing a carbon source directly available for the micro-organisms and at a high concentration.

Q16: Do you check the possible emission of N₂O to the air to be minimized? how?

A16: The emission of N₂O was not measured. We try to create optimal conditions to ensure a complete denitrification, for example by providing a carbon source directly available for the micro-organisms and at a high concentration.

Q17: For release of P from FeO pot-trials; what soil was used? Is a high fungal soil content maybe a solution to mining the phosphate from iron, and make it plant-available?

A17: The used soil is just the regular peat composition normally used in the cultivation of ornamentals. Your suggestion could have a positive effect, although I'm afraid that that effect will be very small. The P is really strongly bound to the grains and migrates even into the core of the grains.

Q18: Are phosphate solubilizing bacteria iron reducers? what is the mechanism by which they dissolve the P?

A18: Please address your question to an expert with PSB's like Leen De Gelder: leen.degelder@ugent.be

Q19: The desorption of P does this work fine also when a biofilm is coating the filter materials?

A19: Deposits of any material (inorganic/organic) on the filter material is always detrimental to the adsorption (and desorption) capacity, therefore it is recommended to remove as much particulate material as possible before pumping the drainage water to the adsorption filter and if necessary, backwash the filter on a regular basis.

Q20: Does the recovery produce the same filter material capacity for the second use in the filter unit?

A20: The adsorption capacity decreases as a function of the number of cycles, even up to 40-50% of the original adsorption capacity in some specific cases. This was demonstrated in preliminary experiments on a laboratory scale. The adsorption capacity after alkaline desorption does strongly depend on the type of adsorbent material used and the EBCT applied and is influenced by the presence of calcium deposits on the outside of the filter material. An additional acid rinse before alkaline desorption can provide a solution for the calcium deposits.

Q21: What was the P load in the ICS used in the pot experiments?

A21: The saturated ICS granules derived from a pilot adsorption column at a florist contained 15 mg P/ g DS. This composition was determined by first destroying the granules through Aqua Regia and then performing an ICP analysis. When exposing the same ICS granules to a 1 molar NaOH solution for 24 hours, only 8 to 9 mg P/ g DS could be desorbed from the granules, indicating that the phosphorus in this case is strongly bound to the filter material (most likely due to the long contact time allowed in the filter bed).

Q22: Have you continued the long contact time after 280 days? as you only got 1 value for C/Co=1 and 2 values of C/co around 0.7.

A22: After the 280 days, we stopped the experiment. We still have the saturated materials for further analysis. Experiments with different cycles of adsorption and desorption are still planned, but only for short residence times in the filter (< 0.5h), because in this situation the regeneration is obviously very important to delay the breakthrough time. We would like to work with cycles of 5 days of adsorption and a subsequent alkaline desorption phase and washing.

Q23: How may days did you leave between the adsorption and desorption experiment? I think this might be important in changing the strength of the Fe-P bonds

A23: Desorption was performed immediately after the adsorption phase. The same flow rate through the column was used. We also know that dwell times give rise to increased adsorption capacity, and

probably difficult desorption. We mainly notice low desorption capacity when a high residence time is maintained during the adsorption phase. The high EBCT gives rise to migration of the P deeper into the filter material, making desorption more difficult. The migration of the P also explains the higher adsorption capacities that can be achieved at long residence times in the adsorption column and this even at very low influent concentrations.