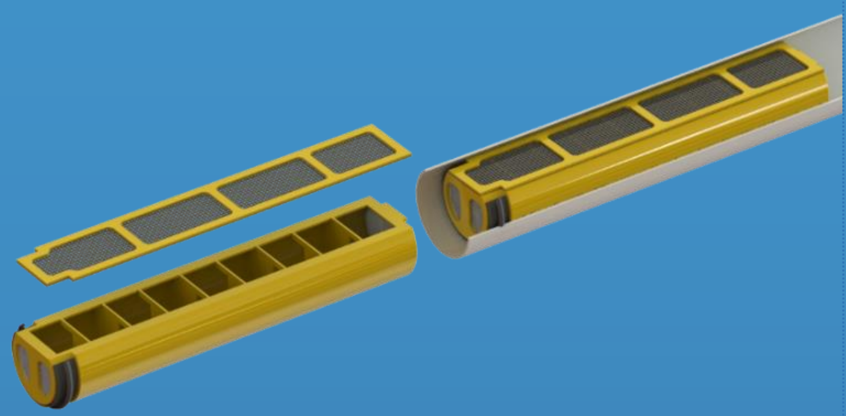
FACTSHEET

A FILTER SYSTEM FOR SUBSURFACE DRAINAGE WATER TREATMENT USING BIOCHAR



Key information

This technology provides a filter structure that can be inserted to a drainage pipe outlet to retain nutrients from subsurface agricultural drainage water. The structure can be reused by filling it with new filter material each time the filter is saturated, and the loaded filter material can be used directly as fertilizer.

Target audience: researchers, farmers, farm schools.

This project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement No 858735.

A. Brief Introduction:

The filter system is an in-pipe cartridge filter system developed by alchemia-nova to retain nutrients from subsurface agricultural drainage water. The structure is inserted at the end of the existing drainage pipe. It is currently being tested at field scale in Gleisdorf, Austria. The main advantages of this experimental prototype are that the structure is easily inserted/removed in the existing drainage pipe, the structure can be reused again by filling it with new filter material every time that the filter is saturated, and the loaded filter material can directly be used as fertilizer.

B. Design concept and experimental set up:

The system is designed to mimic a horizontal flow filter system but at a small scale, and is inserted in the drainage pipe at the outlet. Drainage water flows through a filter structure and exits it. The cartridge filter structure is made using a 3D printer. The structure has the precise dimensions to fit tightly in drainage pipe.

The performance of such system in terms of nutrient retention is investigated in a real drainage pipe in Gleisdorf at an organic farm. Two cartridges are inserted in the drainage pipe. Dimension of each cartridge were: 700 mm long, 74.5 mm radius, 149 mm height, and volume of 8 L. The cartridge structure was filled a substrate media like biochar which can retain P and N present in drainage water. To ensure sufficient hydraulic conductivity, the multi-layer filter consisted of 4-8 mm zeolite in the first structure, and MgOH coated biochar produced by cherry seeds. Previously tested biochar tested was too fine for this kind of solution. The filter was removed after 32.8 m3 of water had passed through the filter (over 110 days). During periods of intense rain-event there was overflow and sedimentation was observed on top of the filter as well as inside. The results of some sampling points showed that effluent concentrations decreased passing from influent, effluent of 1st structure, to final effluent after the 2nd structure. But this was not observed continuously.

Prior to this application, the biochar was tested in laboratory to assess sorption properties of the material. Sorption curves for PO_4, NO_3, NH_3 were determined with a range of inlet concentrations varying from 0 to 25 mg/L. Biochar did not arrive the saturation point at these concentrations. Columns experiments are currently being carrying out at Boku to assess nutrient capacity of zeolite and biochar under different flow rates.

Fig. 1. Cartridge, location at drain pipe exit, and the experimental set-up.

C. Technical information:

Information about the subsurface drainage water treatment solution:

i. Requirement for installation/use.

The solution is placed in a drainage pipe (KG160). The outlet must be accessible for insertion and unmounting filters. Also the drainage pipe must be straight to allow to allow to insert the required number of filters.

ii. Requirement for operation and maintenance

Periodic monitoring (once a month) of the drainage pipe to treat possible hydraulic (clogging) or overflow issues (i.e., heavy rain event can lead to washout of fine sediments from soil, that may clog filter or water meter). Exchange of filter medium, once the filter is saturated. No special skills are required to maintain the system if it works properly, short instructions are sufficient training for maintenance.

D. Costs and Benefits:

i. Cost of installation, materials and equipments:

- filter structure 3D-printed: 72 € /unit
- Sieve front and back 3D-printed: 70 € /unit
- Other materials: coupling sleeve, lid for drainage pipe, rope, tube clamp: 130 €

- Substrate costs: Biochar coated with MgOH (1500 € / m^3), zeolite 4-8 mm costs
- Working time (up to 2h), 3D-printing of one filter + preparational work (8h of which 6h are printing time)
- Watermeter costs
- Water analyses equipments, reagents, and working time costs.

ii. Farming and environmental benefits:
- Product/by-product marketing (e.g., circular economy, climate change adaptation/mitigation, reduction in disposal costs)
- Filters are printed with bio-based plastics (PLA) and can be shredded and reused for further printing.
- No additional land area is occupied, which leads to habitat protection

iii. Environmental consequences:
- 3D-printing needs electricity - overall input would be cheaper with injection moulding - but needs high amount of production pieces
- When using biodegradable plastics, potentially produced microplastics through surface scratches or similar are also harmless.

iv. Social consequences:
- Through easy handling more individuals can be reached and inspired to care (more) about water usage and nutrient recovery locally

E. Challenges and opportunities

i. Possible degradation of PLA through exposure to water flow. Local drainage pipe must be accessible without risks
ii. Biochar / charcoal is reported to bind phosphorus. The period of exchanging filter media is to be assessed and optimized based on local conditions (inflow, fertilizer use, etc.)
iii. This in-pipe cartridge could provide a niche solution in addition to other forms of filter media enclosure

F. Reference and demonstration:

Reports and Deliverables of WATERAGRI project:

i. Deliverable 4.3 Description of development of drainage solutions
ii. Deliverable 4.7 Progress report on the development of the nutrient recovery solutions
iii. Deliverable 4.5 Advanced use of biochar for nutrient retention
iv. Deliverable 5.3 Data collected from Case Study facilities.
v. Project Website: https://wateragri.eu/wateragri-solutions/

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