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Moving Bed Biofilm reactor: Case study Belgium

Implementation and results

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Considerations design MBBR concept

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Tile-drained agricultural fields

- 10 – 40 mg NO_3-N/L
- High flow rates (7.5 – 15 m^3/d)
- November – April

Greenhouse effluent

- 20 – 100 mg NO_3-N/L
- Low flow rates (3 m^3/d)
- During the whole year

Design considerations

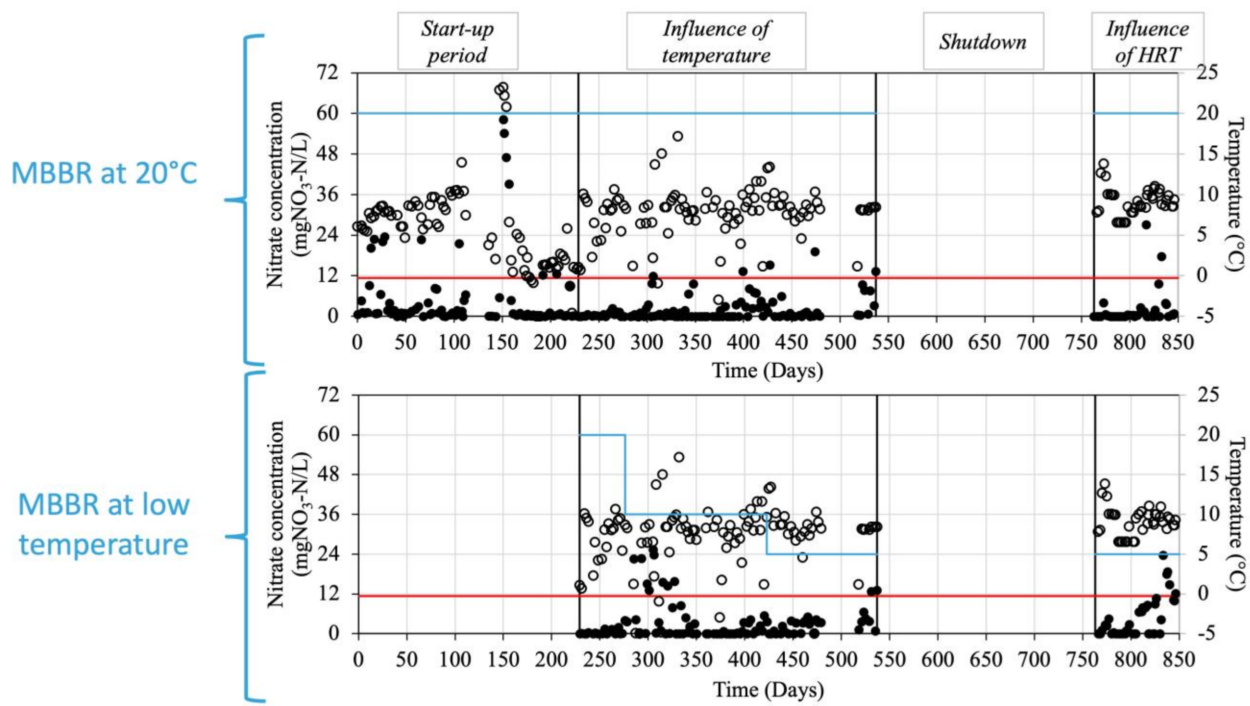
→ Simple and robust system
→ Low water temperatures (between 5 – 15 °C)
→ Variable flow rates and nitrate concentrations
→ Remote locations
→ Low budget solution

Discharge limit: 11.29 mgNO_3-N/L

Feasibility study: methodology

Long term experiment: 850 days

- Total Volume: 15 L with $f_l = 0.85$
- Carriers: AnoxKaldnes K1™ (500 m^2/m^3)
- Carrier fill: 35%
- C_0 = 150 mg NO_3/L = 34 mg NO_3-N/L
- Glycerol-based carbon source



Feasibility study: concluding remarks

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- **Shortage of carbon source:** Increase of effluent nitrate concentrations

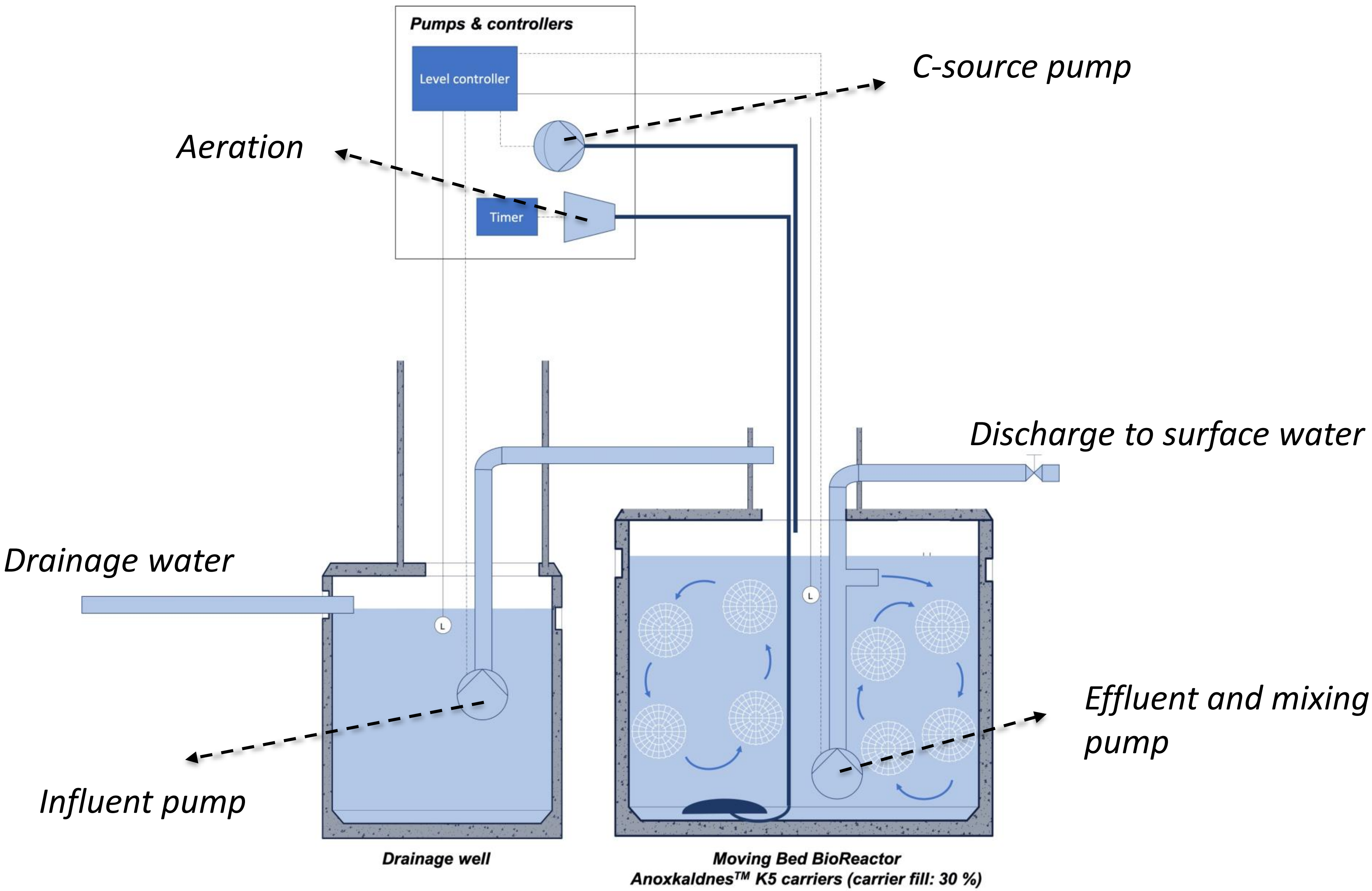
- **Low temperature:** The MBBR is still able to efficiently convert nitrate

- **Influence of HRT:**
  - At 5°C, the removal efficiency significantly decreases by lowering the HRT
  - A minimum HRT of 8 hours is necessary

- **Shutdown**
  - The MBBR can restart immediately, even at 5°C

--- A feasibility study based on GPS-X simulations confirmed our conclusions ---

MBBR concept to treat agricultural waters



Overview MBBRs in the field

	MBBR OLV-Waver	MBBR Putte (MultiLeaf)	MBBR SKW (GONI)
Crops	Cauliflower and chrysanthemums	Lettuce and celery	Lettuce and cress
Type drainage water	Tile drained field	Greenhouse effluent (soil)	Greenhouse effluent (gutter system)
Property	Research Station for Vegetable Production	KU Leuven	GONI
Design	V_{MBBR}= 15 m^3 Q= 15 - 40 m^3/day c_{NO3}= 30-45 mg NO_3-N/L C-source: Carbo ST	V_{MBBR}= 5 m^3 Q= < 3 m^3/day c_{NO3}= 100-200 mg NO_3-N/L C-source: Carbo ST	V_{MBBR}= 10 m^3 Q= 20 m^3/day c_{NO3}= 45mg NO_3-N/L C-source: Molasse
Goals	**Reduction Carbon source** **Optimal mixing conditions**	**Reducing high nitrate content @ high HRT**	**First independent implementation**

Field Case – Tile drained fields

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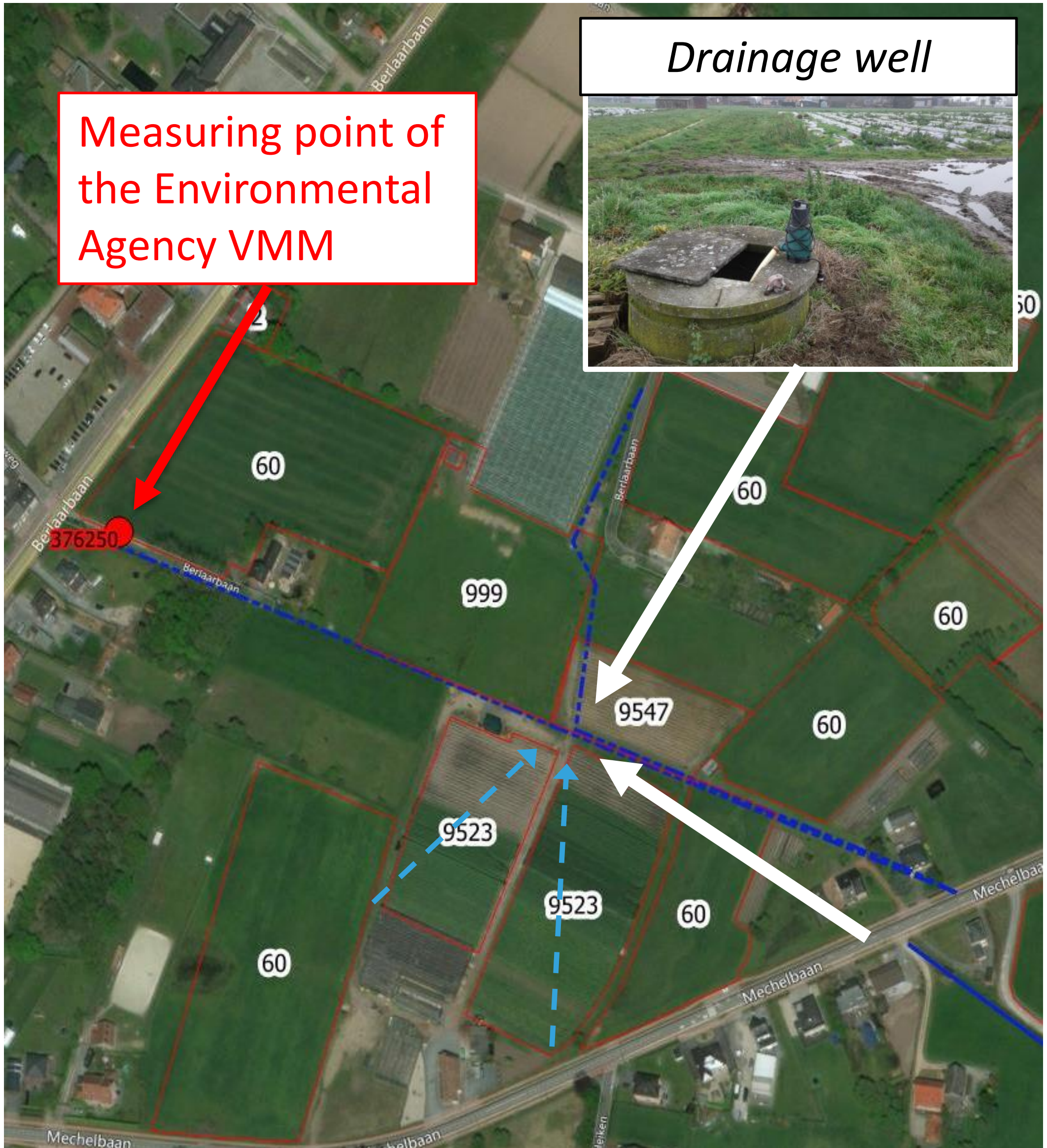

Full scale installation

- V_r = 15 m^3
- Filling degree: 30%
- C-source: glycerol

Field Case – Tile drained fields

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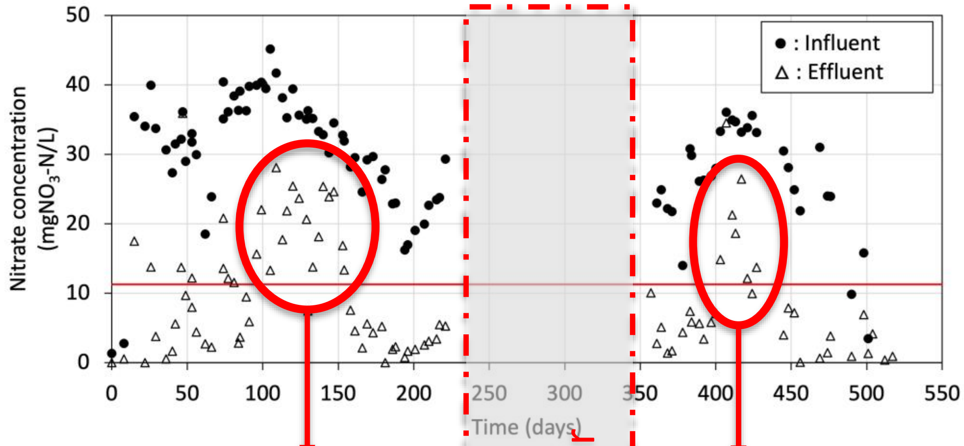
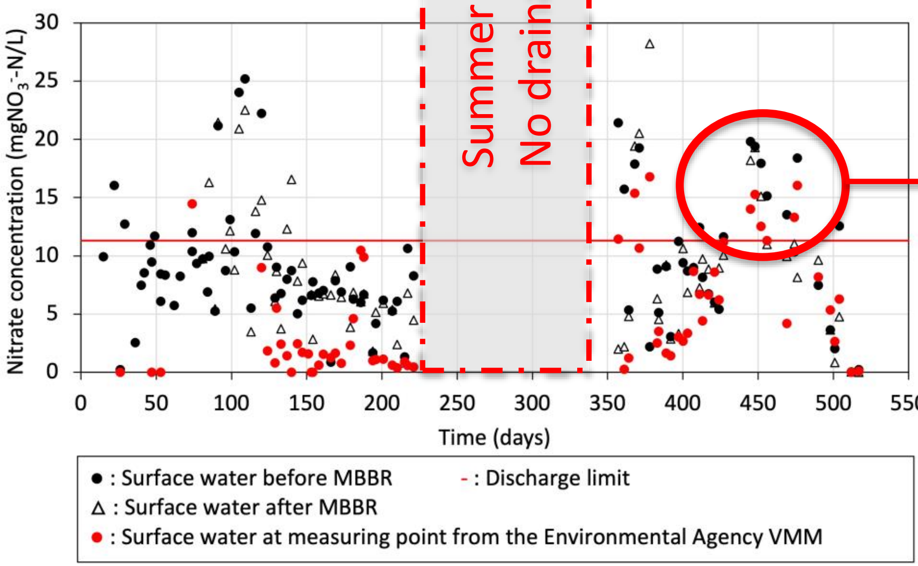


Low removal rate & increase of nitrite concentration
→ Solved by intensified mixing

Low removal rate
→ Carbon source shortage



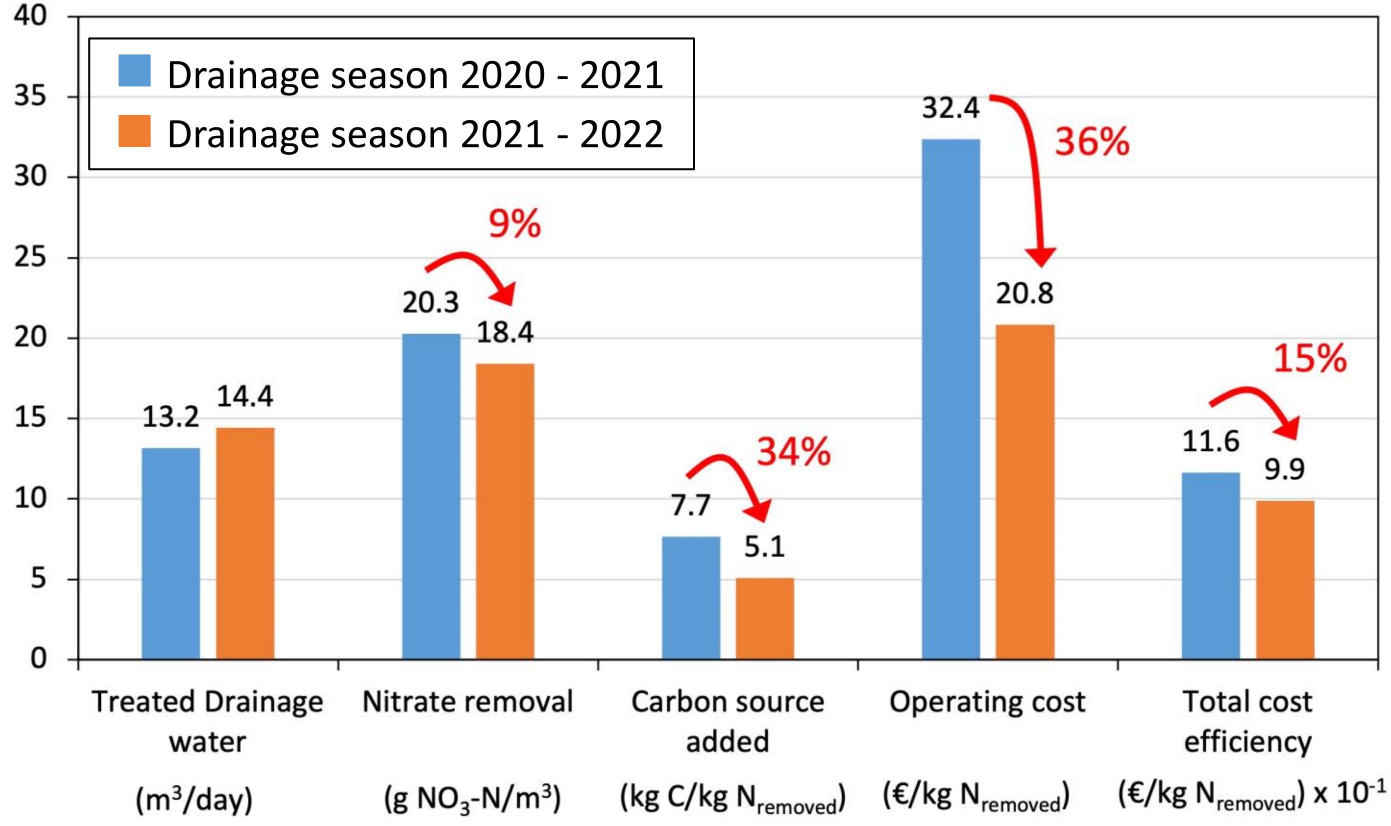
Key numbers	Season 2020-2021	Season 2021-2022
Duration (days)	221	167
Treated Drainage water (m³)	2910	2410
Nitrate removal efficiency	70%	74%
Nitrogen removal efficiency	59%	63%
Average nitrate concentration influent (mg NO_3-N/L)	32	29
Average nitrate concentration effluent (mg NO_3-N/L)	11	8
Maximum nitrite concentration effluent (mg NO_2-N/L)	18	15
Average carbon concentration effluent (mg C/L)	120	74

Nitrate concentration in the surface water was above the threshold value.

→ The farmer decided to pump directly from the drainage well to the water stream.

Field Case – Tile drained fields

- Effect of reducing the amount of carbon source



Field Case – Greenhouse (DIY-concept)

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HOW DO I BUILD A MOVING BED BIOFILM REACTOR (MBBR)?

1. What is a MBBR?

A Moving Bed Biofilm Reactor (or MBBR for short) removes nitrogen from water by converting nitrate into nitrogen gas by means of biological processes. A MBBR consists of a tank filled with water, in which plastic carriers are located that are set in motion (Photo 1Photo 1). The irregular and large specific surface area of the carriers forms an ideal habitat for various micro-organisms (Photo 2Photo 2). On these carriers grows active sludge (biofilm) and this carries out the denitrification.

A MBBR requires little maintenance and is simple to construct yourself with the help of this information sheet.

Photo 1: Set-up of Moving Bed Biofilm Reactor (MBBR) at PCS Ornamental Plant Research

Field Case – Greenhouse (DIY-concept)

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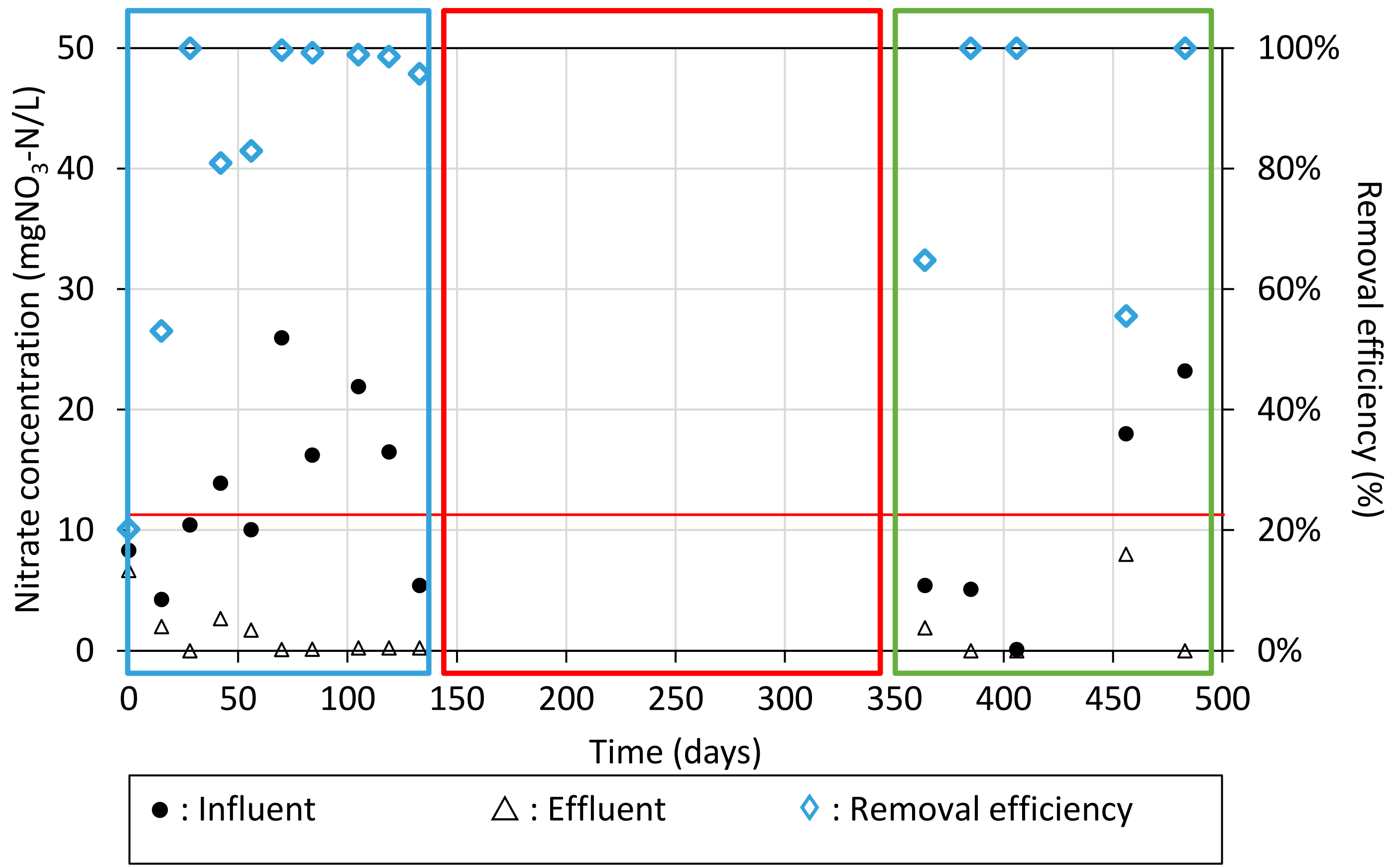
Storage pond: Day 0 - 133
- Influent: 13.3 $mgNO_3$-N/L
- Effluent: 1.4 $mgNO_3$-N/L
- Removal efficiency: 83%

Shut down during the winter

Drain water: Day 364 - 483
- Influent: 10.4 $mgNO_3$-N/L
- Effluent: 2.0 $mgNO_3$-N/L
- Removal efficiency: 84%



Concluding remarks

- **Start-up period - Shutdown**
  - The first drainage season: removal efficiency is lower
  - The MBBR can restart immediately after a summer period
- **Influence of temperature**
  - The MBBR is able to efficiently convert nitrate at low temperatures
  - The underground concept limits the temperature fluctuations
- **Challenges**
  - Treatment of high concentrations
  - Carbon & biomass release to local water streams – post-treatment?
  - Clogging of the carriers due to suspended solids (greenhouse effluent)
  - Economic feasibility for agriculture
  - Awareness and the limitations of the technology

Q & A