DeWaResT

DECENTRALISED WASTEWATER TREATMENT AND WATER REUSE FOR REGIONS WITH SEASONAL DROUGHT STRESS

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Federal Ministry of Education and Research

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Motivation

Case Study

DeWaResT

De → **<u>Decentralised wastewater treatment:</u>**
Alternative to septic tanks in rural regions

Wa → **<u>Water reuse:</u>**
Reducing water scarcity through the reuse of treated wastewater.

ResT → **<u>Regions with seasonal drought stress:</u>**
Many regions in the world suffer from drought stress
→ Transferability

Objectives

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- Testing and optimization of a novel aerated vertical CW with a reduced footprint
- Increasing the efficiency of nitrogen and phosphorus removal
- Demonstrate robustness to shock loading
- Demonstration of potential water reuse through compliance with specified effluent quality

Specified effluent quality:

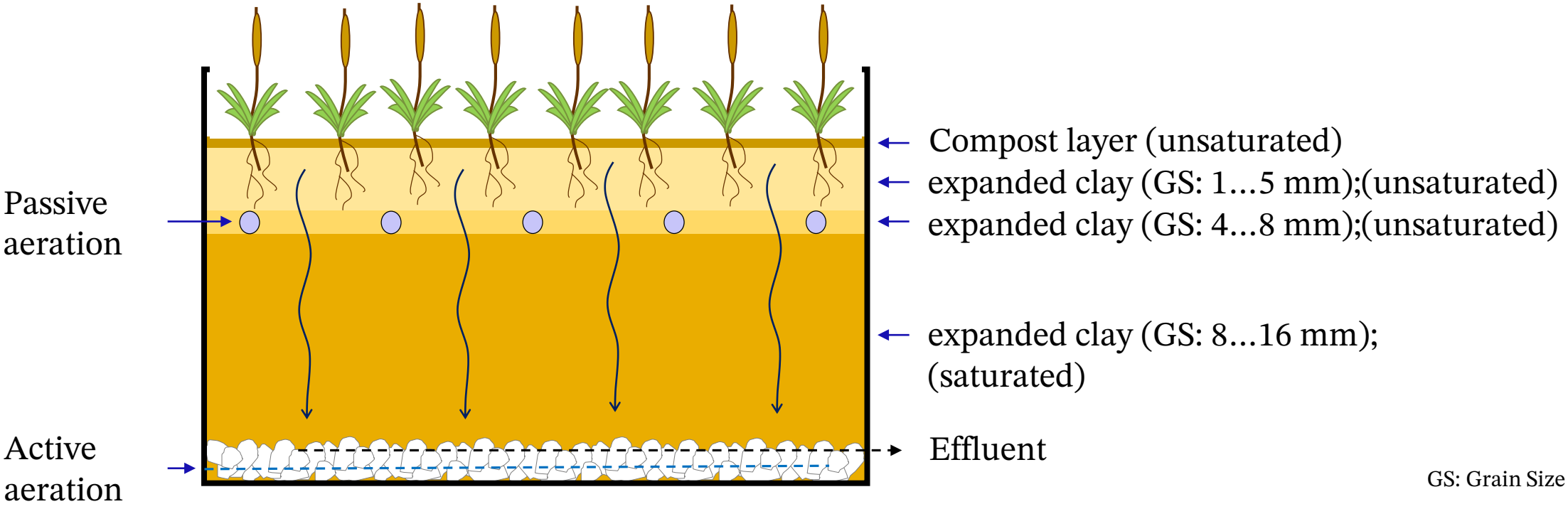
- COD < 75 mg/L
- BOD_5 < 15 mg/L
- NH_4-N < 10 mg/L

- $N_{inorg.}$ < 25 mg/L (DIN)
- TP < 2 mg/L

- E.Coli < 100 CFU/100 mL

References: DWA (2019) DWA Arbeitsblatt A-221: Grundsätze für die Verwendung von Kleinkläranlagen. Hennef.

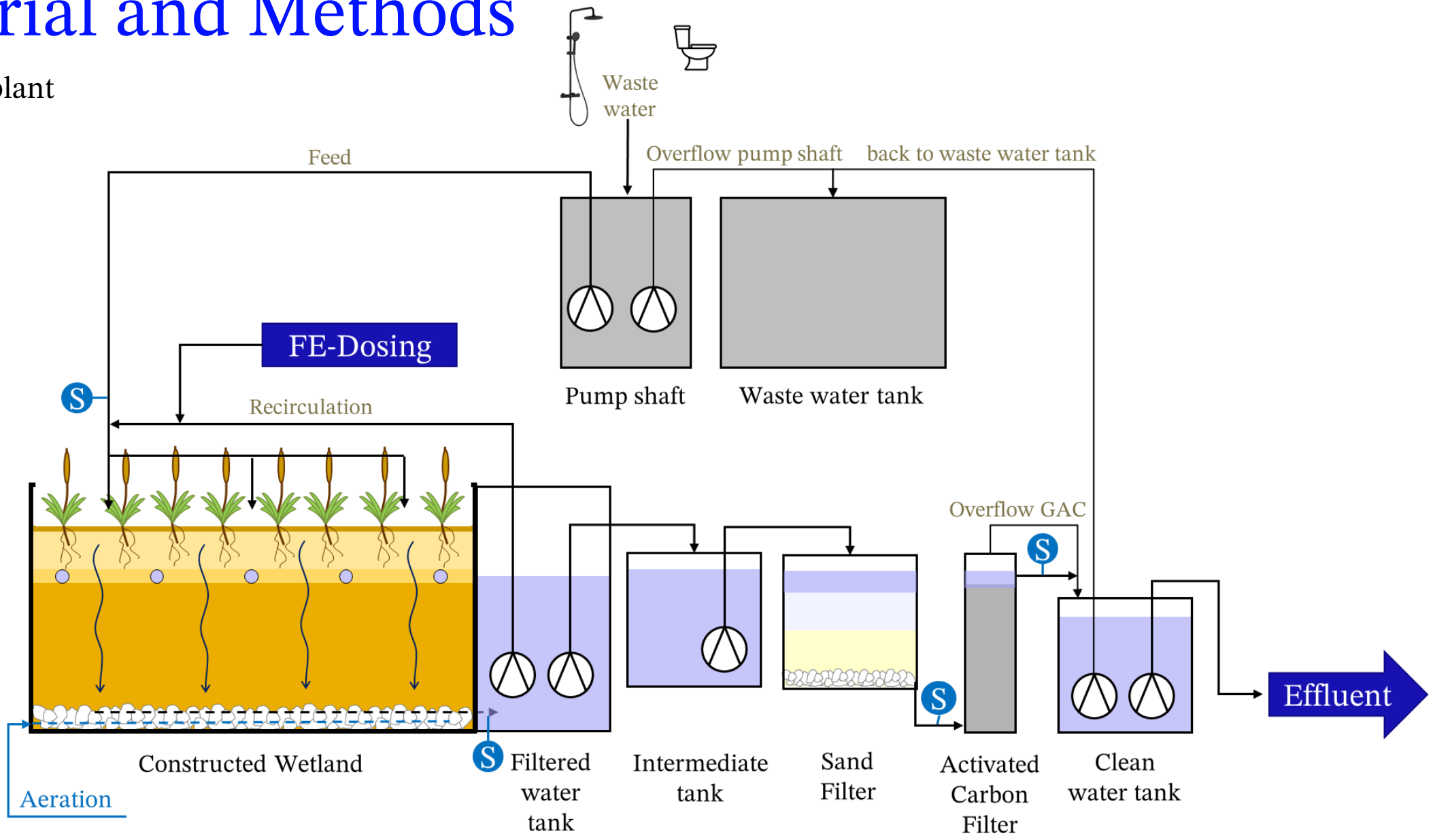
Material and Methods



- Vertical multi-layer design
- both stages (nitrification and denitrification) are combined in one chamber
- Lower space requirement than conventional constructed wetlands

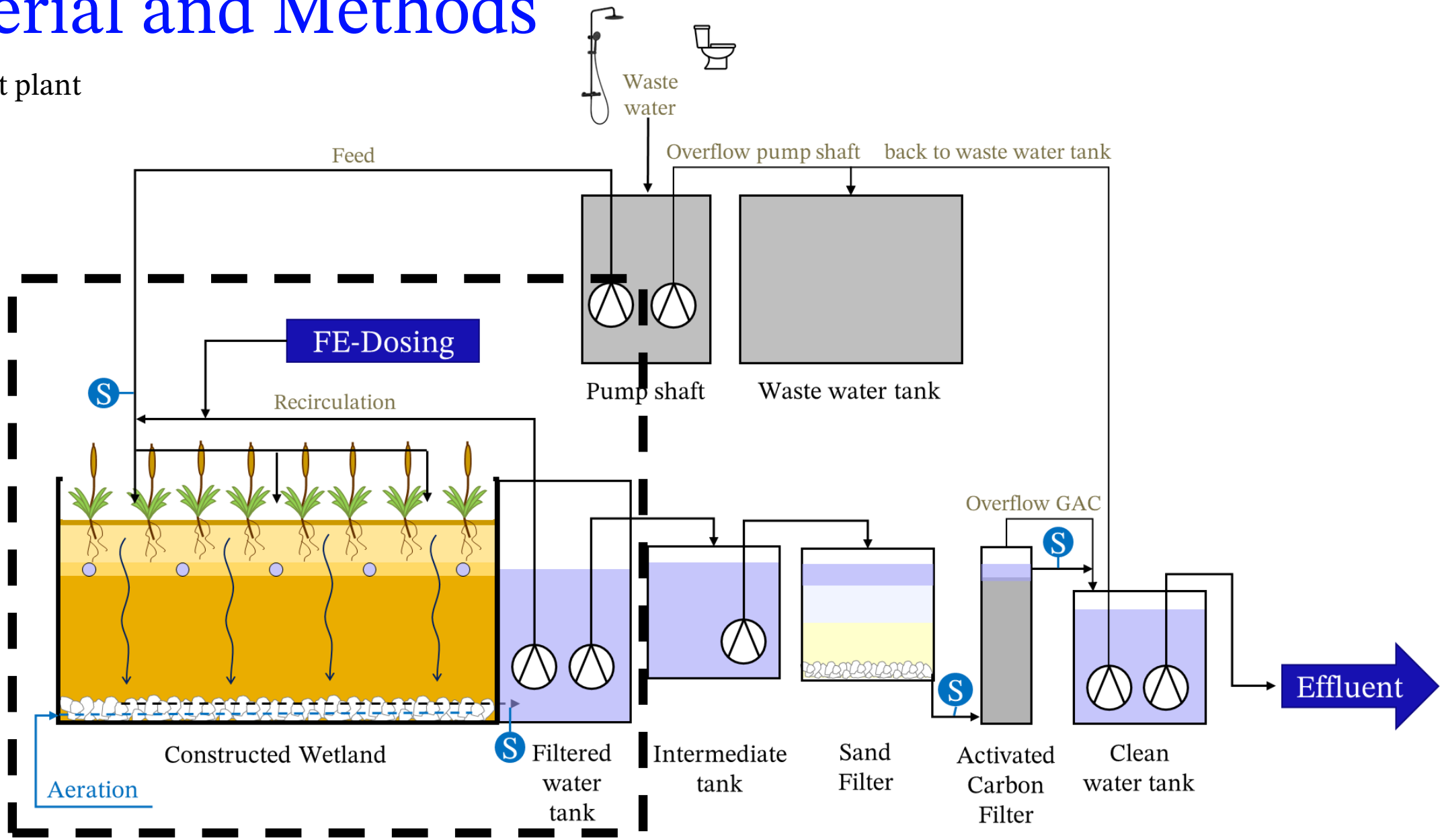
Material and Methods

Setup Pilot plant



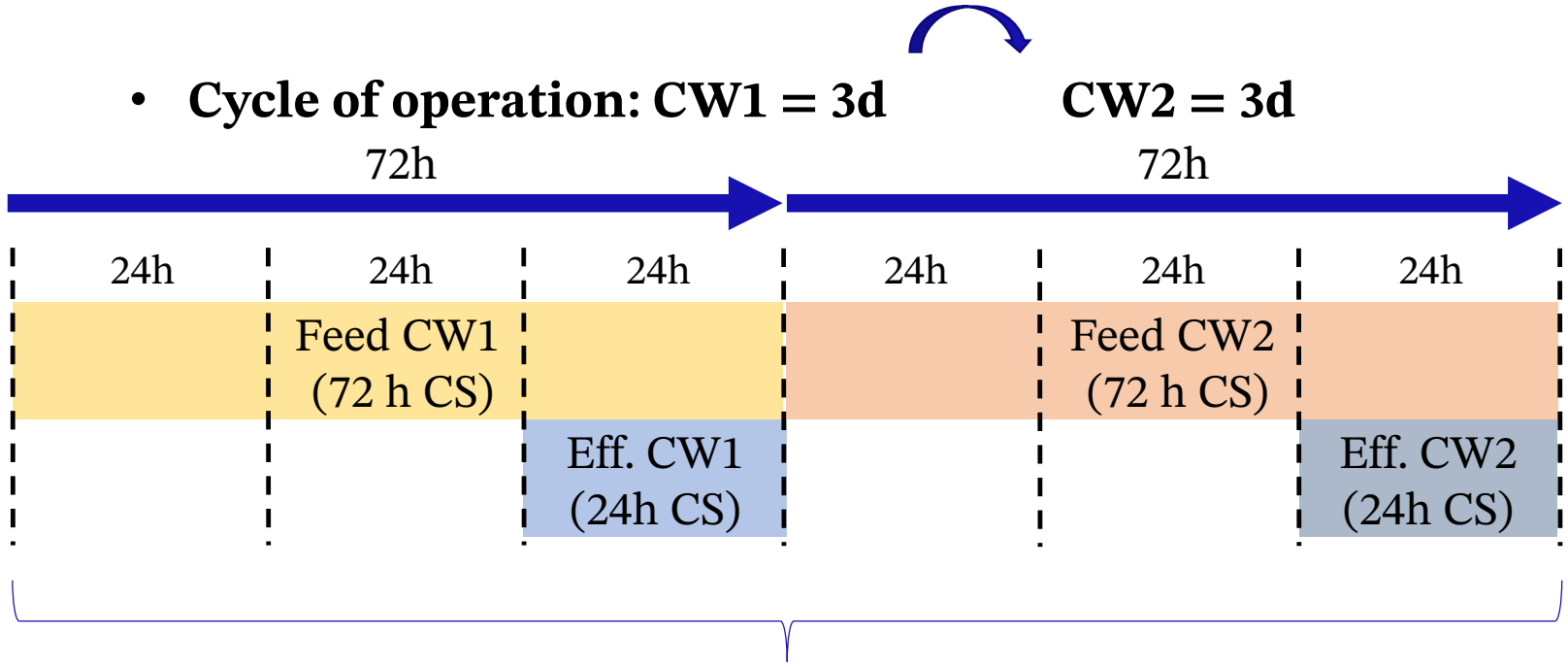
Material and Methods

Setup Pilot plant



Material and Methods

- maximum feeding per day → **1.1 m^3/d** (variation between 0 … 1.1 m^3/d)
  → HRT ≅ 4 d at 1.1 m^3/d feeding
- Recirculation ratio→ **R = 200 %** (variation between 100 … 400% of feeding)
- Aeration time per day → **AT = 12 h/d** (variation between 4 … 16h/d)
- **Cycle of operation: CW1 = 3d** **CW2 = 3d**



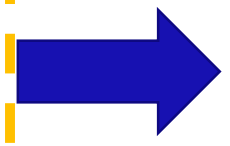
sampling strategy

CW: Constructed Wetland
CS: Composite Sample

Initial situation

Reference: *ATV-DVWK-A 131, 2000

Parameter	typical wastewater* [mg/l]	**case study [mg/l]**
COD	800	**2056 ± 734**
BOD_5	400	**665 ± 355**
TSS	467	**962 ± 479**
TN	-	**208 ± 42**
TKN	73	-
NH_4-N	53	**118 ± 24**
TP	12	**28 ± 12**



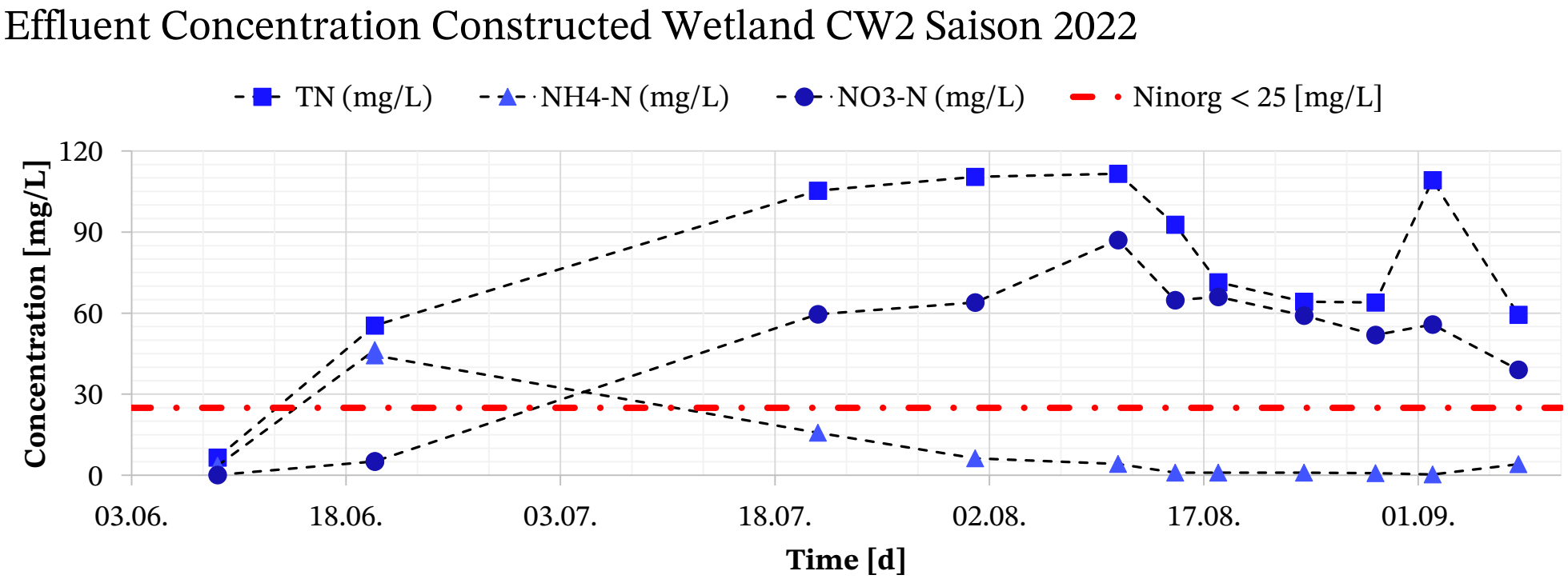
specific water consumption [L/(d*PE)]
typical wastewater* 150 L/(d*PE)
case study 65 L/(d*PE)

→ Very high load in comparison to typical municipal wastewater

→ Low specific water consumption ➔ 65 L/d

→ COD/BOD ≈ 3

Results focusing on nitrogen removal

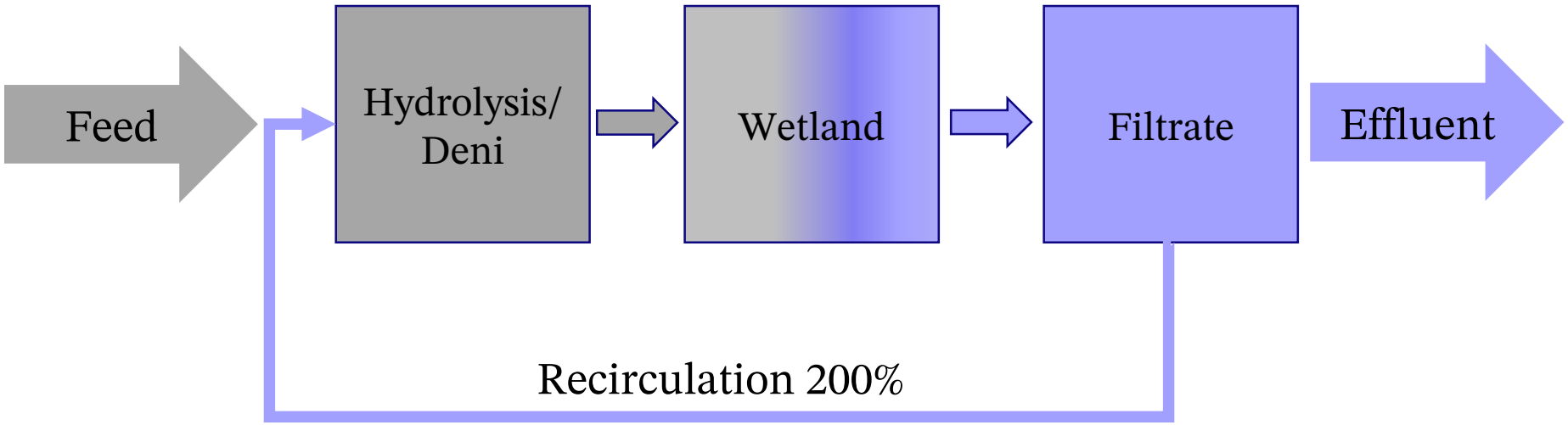


- Overloading the filters at the beginning of the season
- no established biofilm at the beginning of the season
- too low aeration time at the beginning --> low nitrification performance
- too high aeration time during the rest of the season --> denitrification inhibited

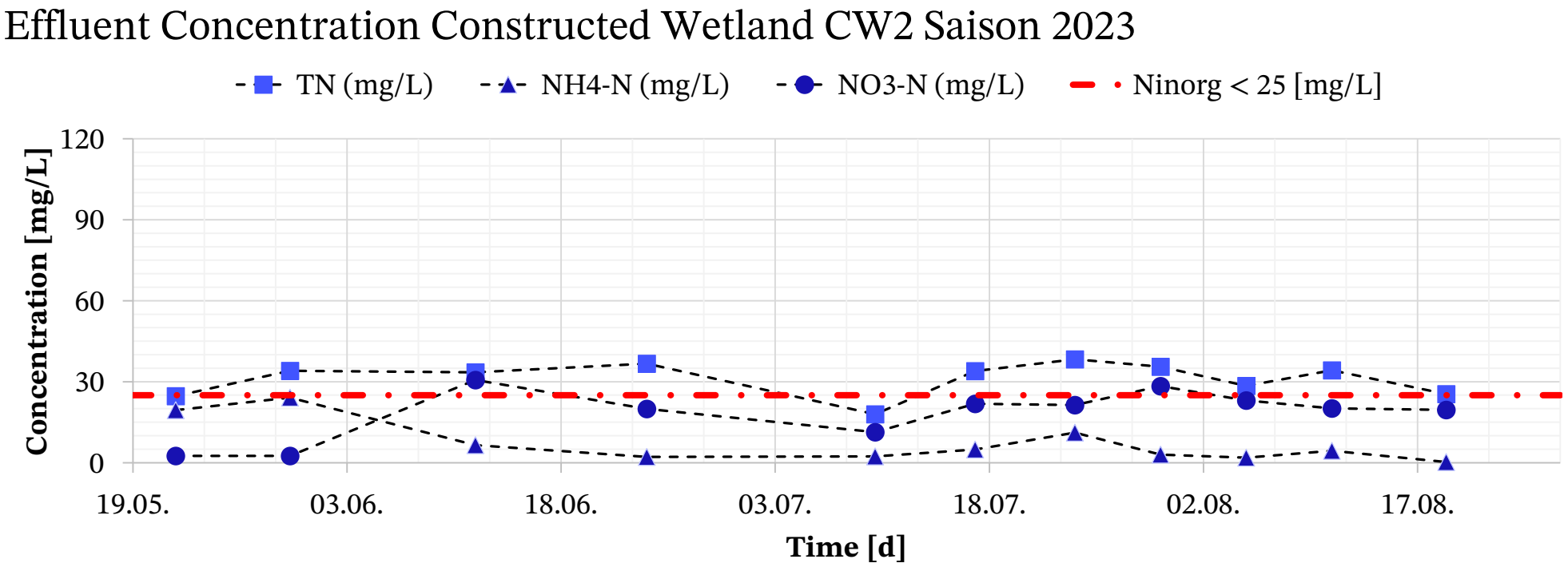
Results focusing on nitrogen removal

Optimisation

- Expansion of the plant through upstream hydrolysis/denitrification
  - Improving the availability of biodegradable COD
  - Creation of additional denitrification volumes
- Optimization of the aeration regime (adaption of aeration time per day)



Results focusing on nitrogen removal



- upstream hydrolysis/denitrification was implemented
- Optimized aeration timing

Efficiency

Effluent Concentration Constructed Wetland CW2 Saison 2022

CW 2	COD [mg/L]	TP [mg/L]	TN [mg/L]	NH_4-N [mg/L]	NO_3-N [mg/L]	NO_2-N [mg/L]	N_{inorg} [mg/L]
Mean ± SD	73 ± 29	0,5 ± 0,3	79 ± 34	12 ± 17	45 ± 29	6 ± 6	62
No.	9	10	10	11	11	10	10
Efficiency [%]	97	98	57	89	-	-	-
	☺	☺	☹	😐	☹	☹	☹

Effluent Concentration Constructed Wetland CW2 Saison 2023

CW 2	COD [mg/L]	TP [mg/L]	TN [mg/L]	NH_4-N [mg/L]	NO_3-N [mg/L]	NO_2-N [mg/L]	N_{inorg} [mg/L]
Mean ± SD	64 ± 7	1.7 ± 0,3	31 ± 6	6 ± 6	18 ± 9	0.3 ± 0.3	25
No.	11	10	10	11	11	10	10
Efficiency [%]	97	95	83	95	-	-	-
	☺	☺	😐	☺	😐	☺	😐

Conclusion

- Very high performance in terms of COD and TP elimination of approx. 96%.
- By adjusting the aeration regimes, an increase in nitrification performance (95%) was achieved.
- Increase of the denitrification performance, up to 85% by process optimisation.
  - Upstream denitrification/hydrolysis
  - Optimized aeration regime
- N_{inorg} concentration lower than 25 mg/L in the CWs effluent despite extremely high influent concentrations
(TN = 208 mg/L).

Thank you for your attention!

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