

Progress Update

Nitrogen Extraction from Water



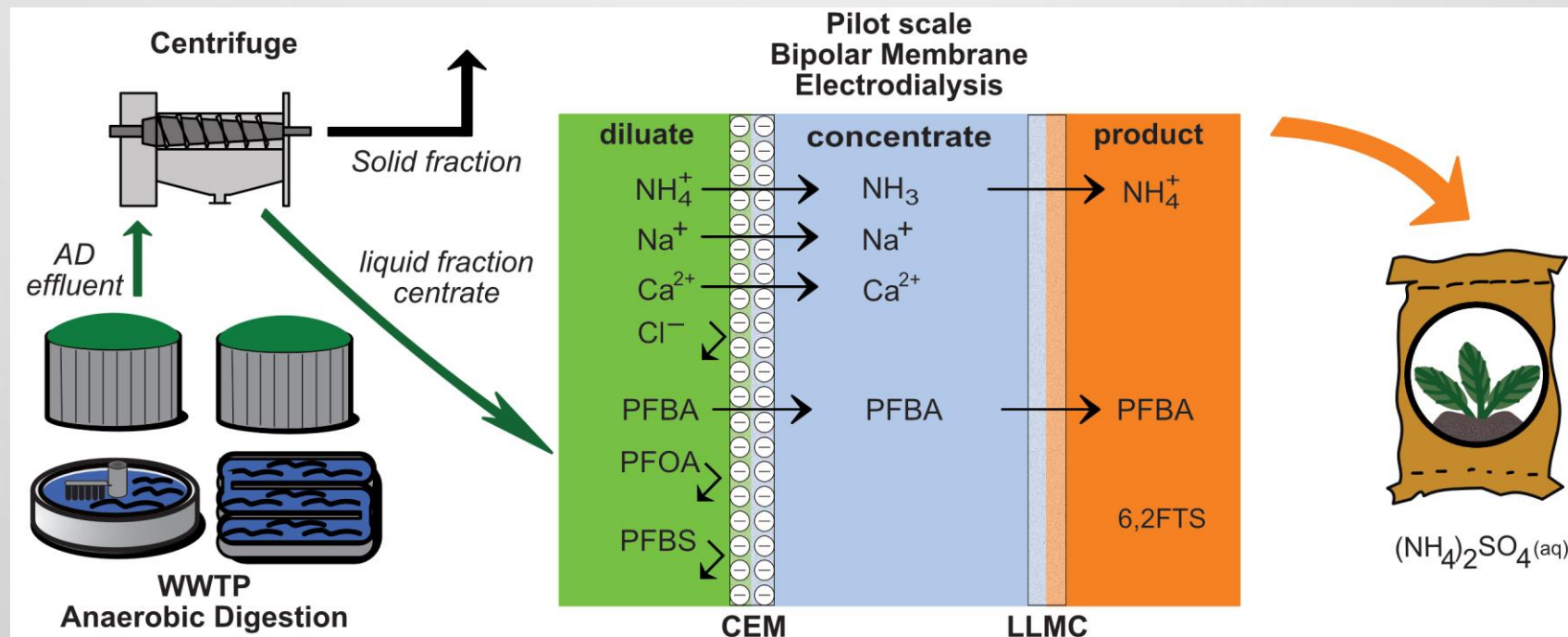
by an Innovative Electrochemical System



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Latest Update Pilot Girona (Catalonia, Spain)



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Highlights: Pilot Girona (Catalonia, Spain)

- NH_3 recovery by Bipolar Membrane Electrodialysis and membrane stripping
- Pilot-scale unit operated onsite using centrate from anaerobic digester
- Scaling was mitigated by automated cleaning-in-place to restore membrane function
- Pilot removes $235.7 \text{ g}_\text{N} \text{ d}^{-1}$, consuming $6.3 \text{ kWh kg}_\text{N}^{-1}$ in intermittent current mode
- Up to $0.25 \text{ } \mu\text{g L}^{-1}$ of 6:2 FTS found in the final product released from Teflon tubing

Operational conditions: Pilot Girona (Catalonia, Spain)

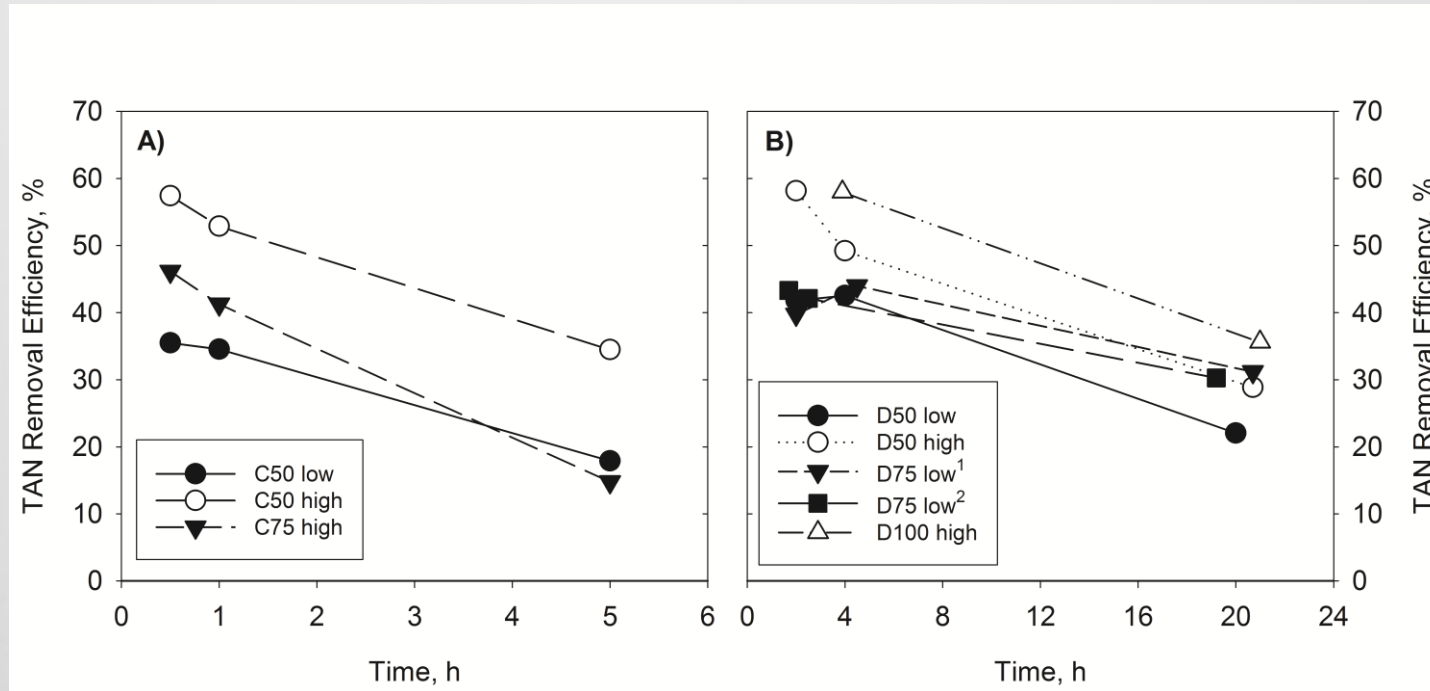
ID	Description of experimental design	L_N
D50 low	Donnan mode, 50 A m ⁻² (current: 20 s on, 60 s off)	1.4
D50 high	Donnan mode, 50 A m ⁻² (current: 20 s on, 60 s off)	1.8
D75 low ¹	Donnan mode, 75 A m ⁻² (current: 20 s on, 60 s off)	1.4
D75 low ²	Donnan mode, 75 A m ⁻² (current: 20 s on, 60 s off)	1.4
D100 high	Donnan mode, 100 A m ⁻² (current: 20 s on, 60 s off)	1.8
C50 low	Continuous mode, 50 A m ⁻²	1.4
C50 high	Continuous mode, 50 A m ⁻²	1.8
C75 high	Continuous mode, 75 A m ⁻²	1.8

Table 1. Summary of the operational conditions of the experiments conducted at the NEWBIES pilot plant. Whereas the letters D and C refer to either Donnan mode or continuous mode of operation, the number (50, 75 and 100) refers to the applied current and low or high refers to the load ration of 1.4 (low) or 1.8 (high).

$$L_N = \frac{J^* A_M}{C_{TAN, Feed\ inflow} * Q_{Feed} * F}$$

The L_N is defined as the ratio between the applied current density and total ammonia nitrogen (TAN) feeding rate

TAN removal efficiencies : Pilot Girona (Catalonia, Spain)



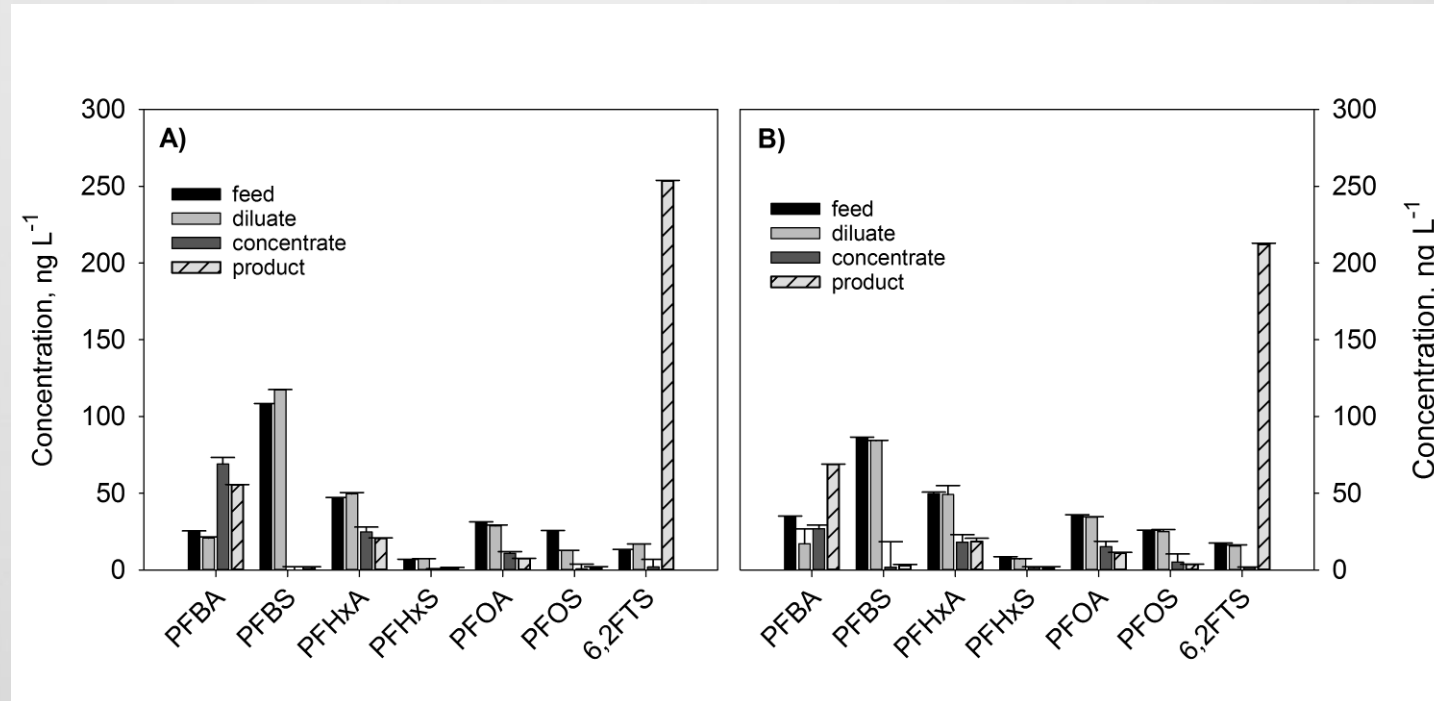
TAN removal efficiencies (%) during continuous (A) and Donnan mode (B). The removal decreased over the experimental time of each condition.

Results: Pilot Girona (Catalonia, Spain)

Table 2. BP-ED performance during Continuous and Donnan mode in terms of specific energy (SE) demand (SE kWh kg_N⁻¹), transport (g_N d⁻¹) and transport rate (g_N m⁻² d⁻¹) of TAN, TAN removed, ammonia recovered (g_N) and product concentration (g_N L⁻¹)

	C50 low	C50 high	C75 high	D50 low	D50 high	D75 low ¹	D75 low ²	D100 high
Transport rate (g _N d ⁻¹)	453.7	562.4	608.0	131.9	131.2	234.6	235.7	282.1
Transport rate (g _N m ⁻² d ⁻¹)	144.2	178.8	193.3	41.9	41.7	74.6	74.9	89.7
SE (kWh kg _N ⁻¹)	17.7	11.8	35.8	6.6	7.5	6.5	6.3	13.3
TAN removed (g _N)	132.1	145.5	152.0	130.1	131.2	227.3	202.1	241.9
Product concentration (g _N L ⁻¹)	27.1 ± 1.4	26.1 ± 2.4	33.2 ± 2.6	26.1 ± 3.3	19 ± 0.8	26.4 ± 2.3	21.4 ± 2.7	18.8 ± 15.4

PFAS Fate: Pilot Girona (Catalonia, Spain)



Concentrations of target PFAS measured in the feed, diluate (mean), cation concentrate (mean) and in the product in: A) continuous current mode, 50 A m⁻², L_N=1.4, t₁=2 h, t₂=20 h, i.e., run “C50 low” and B) Donnan current mode, 50 A m⁻², L_N=1.4, t₁= 1 h, t₂= 5h, i.e., run “D50 low”.

PFAS Fate: Pilot Girona (Catalonia, Spain)

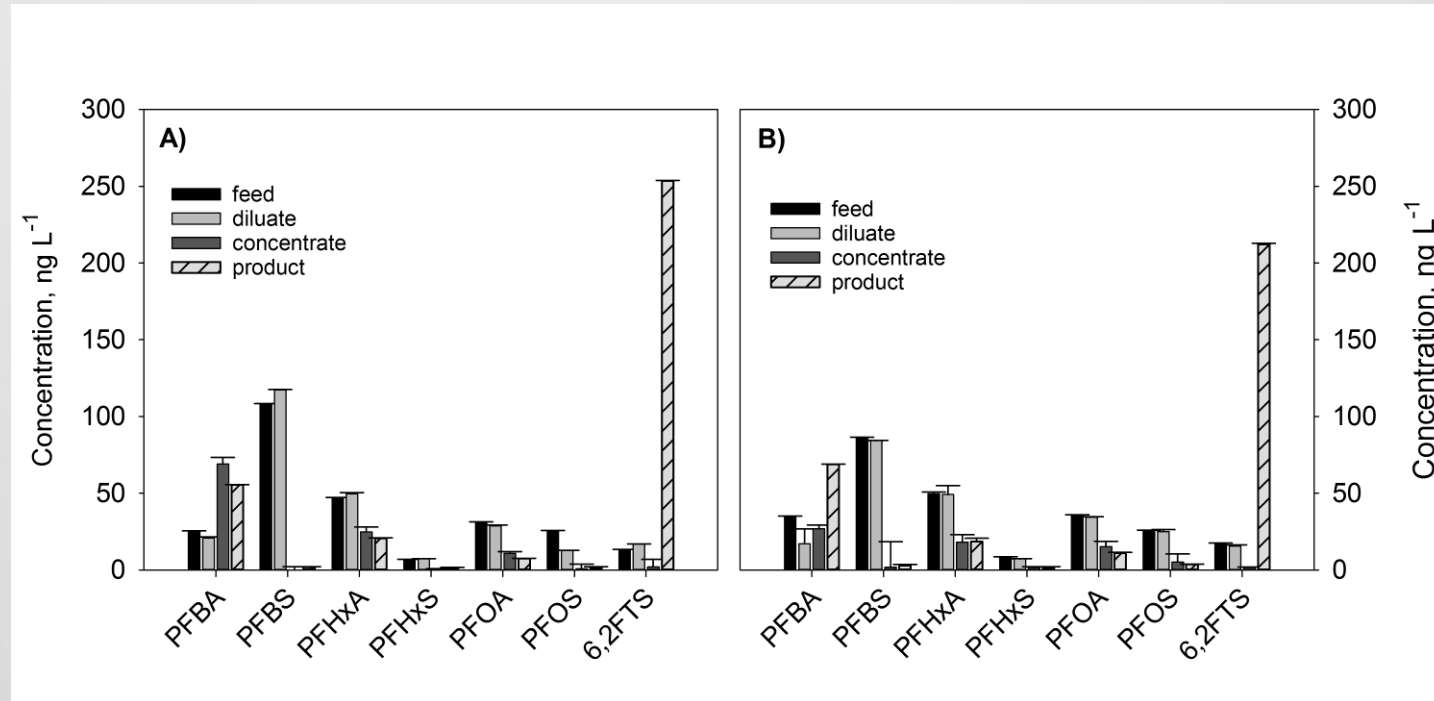
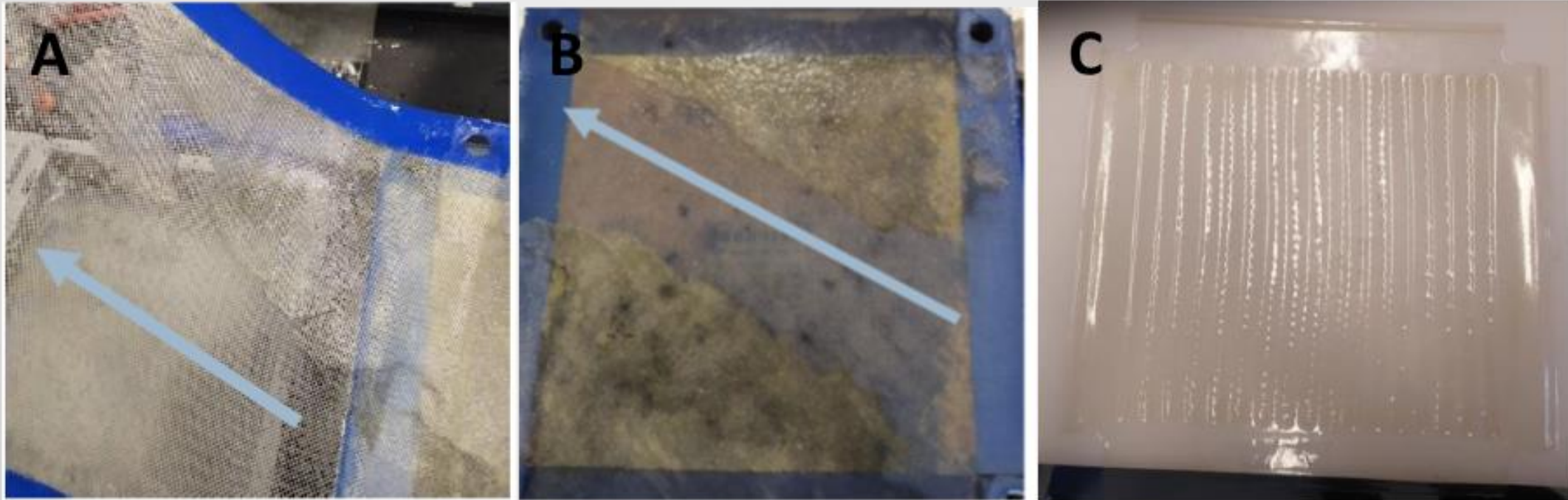


Figure 4. Concentrations of target PFAS measured in the feed, diluate (mean), cation concentrate (mean) and in the product in: A) continuous current mode, 50 A m⁻², L_N=1.4, t₁=2 h, t₂=20 h, i.e., run "C50 low" and B) Donnan current mode, 50 A m⁻², L_N=1.4, t₁=1 h, t₂=5h, i.e., run "D50 low".

Scaling – reuse analysis of IEMs: Pilot Girona (Catalonia, Spain)



Scaling formation in the concentrate flow compartment and cleaned CEM. Arrows indicate the flow direction. A, B) The spacer separating the CEM and BPM was in some pairs fully covered with CaCO_3 and in many cases the scaling formation extended to touch both membranes. C) After cleaning with acid, the scaling was fully removed while the functionality and selectivity of the membranes remained intact.