ESNI CONFERENCE

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ULTIMATE Case Study 2

Nutrient Concentration for Recovery from Greenhouse Wastewater by Electrodialysis

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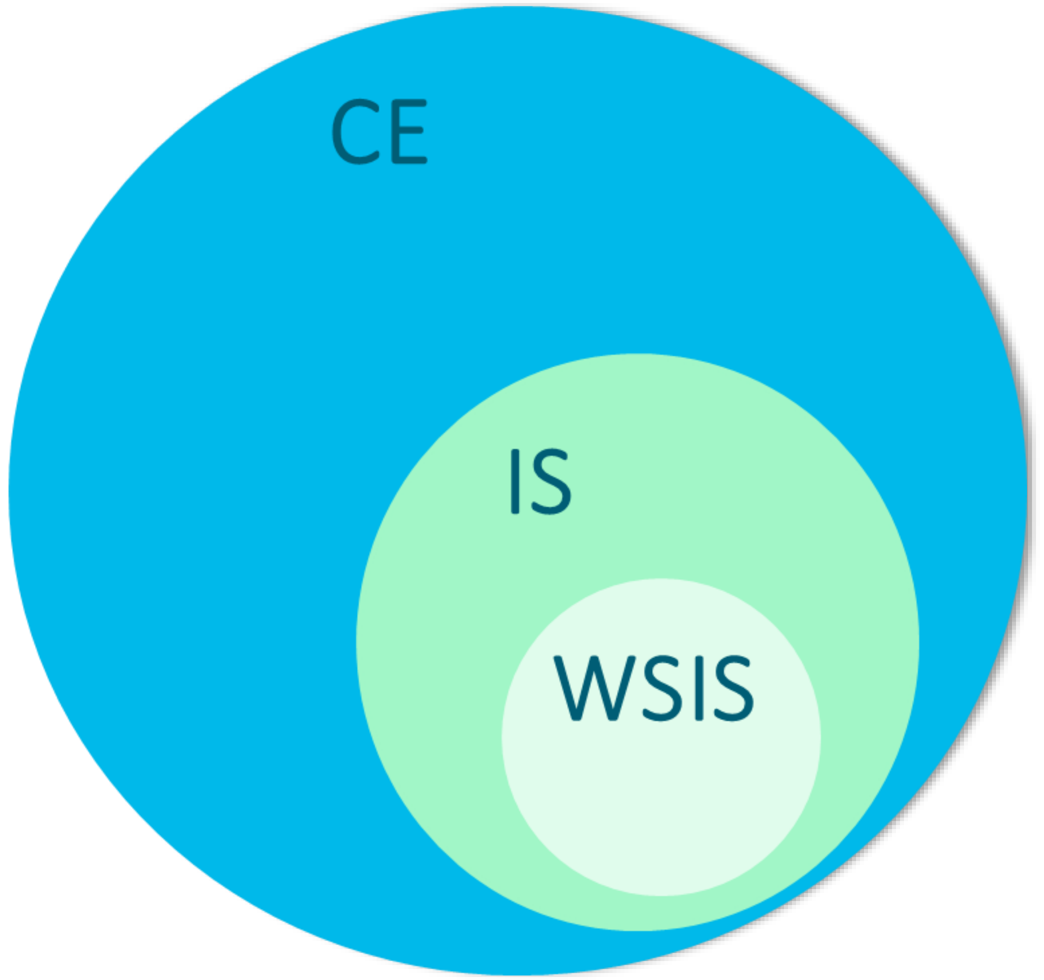
Starting with some definitions

Circular Economy (CE) aims to design waste and pollution management with new value chains, by keeping products and materials in re-use and regenerating natural systems (*Ellen MacArthur Foundation*)

Industrial Symbiosis (IS) aims in bringing together companies from different industrial sectors in order to improve the resource efficiency and sustainability by sharing and reusing resources (*NISP UK*).

Water Smart Industrial Symbiosis (WSIS) aims to create economic value and increased sustainability by introducing circular symbiotic arrangements between industry and water service providers (*ULTIMATE*).



Succes factors for circular transitions

- Enabling technologies
- Digital support tools
- Exploitation/valorisation schemes
- Stakeholder engagement
- Socio-political and governance context

ULTIMATE project

Develop, optimize, and demonstrate Water-Smart Industrial Symbiosis technologies and solutions for:

- **Water reclamation and reuse** (recovery, refining, and reuse of municipal and industrial wastewater)
- **Exploitation of energy and heat** (extraction of energy, combined water-energy management, water enabled heat transfer, storage and recovery of heat)
- **Nutrient and material recovery/reuse** (nutrient mining, extraction/reuse of high-added value exploitable compounds)

Recover, refine and **reuse wastewater,**

Extract and **exploit energy**

Extract and **exploit materials**

Collect and publish information and experience with technologies in a **Technology Evidence Base**

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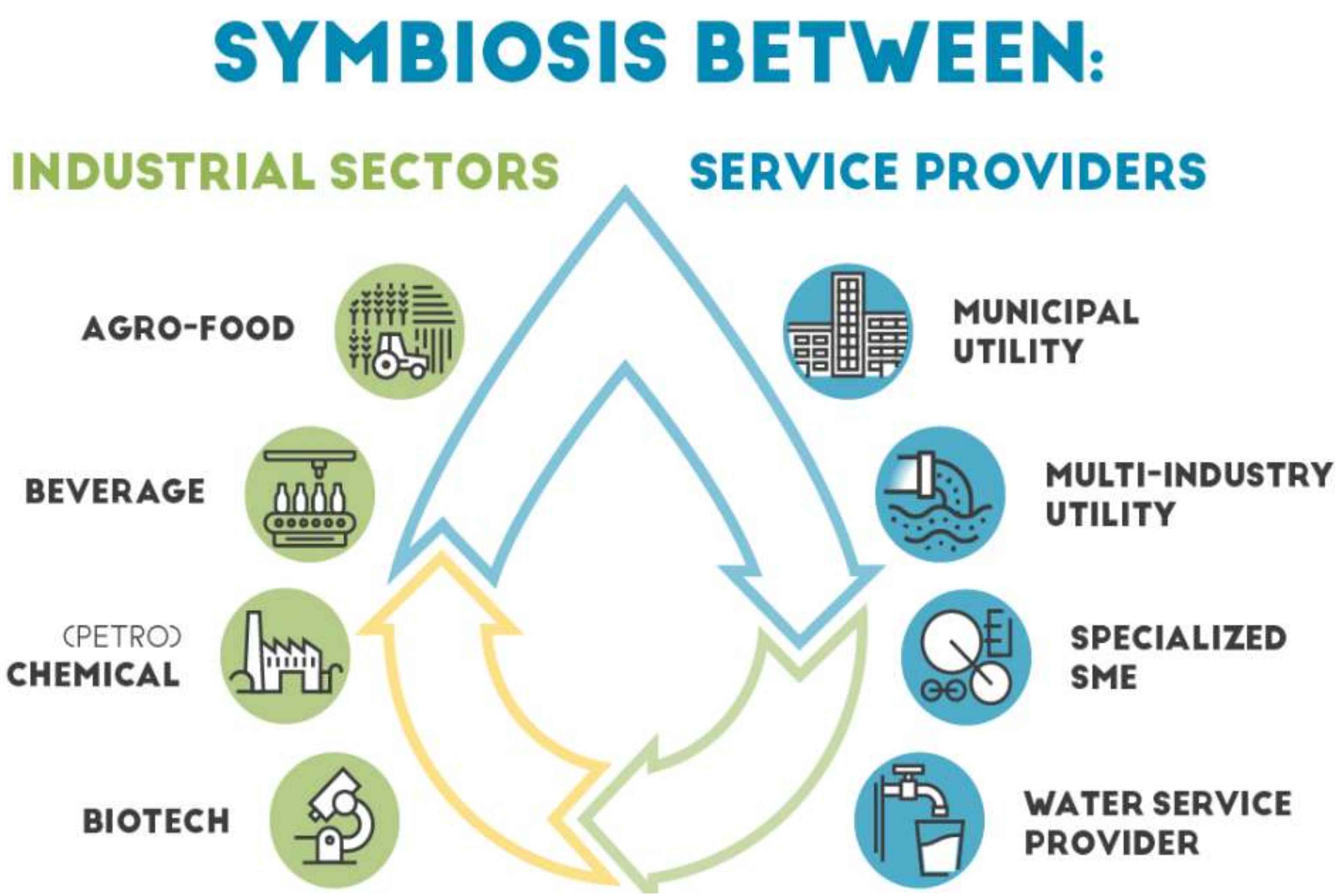
WATER SMART INDUSTRIAL SYMBIOSIS

The project core – integrated case studies



CS2 - Greenhouse Horticulture

- The Netherlands is the second largest exporter of agriculture products (large share from greenhouse horticulture)
- High resource efficiency & production rates – advanced sector!
- Challenges – water scarcity (alternative sources), restrictions in concentrate disposal, strict legislation for effluent quality

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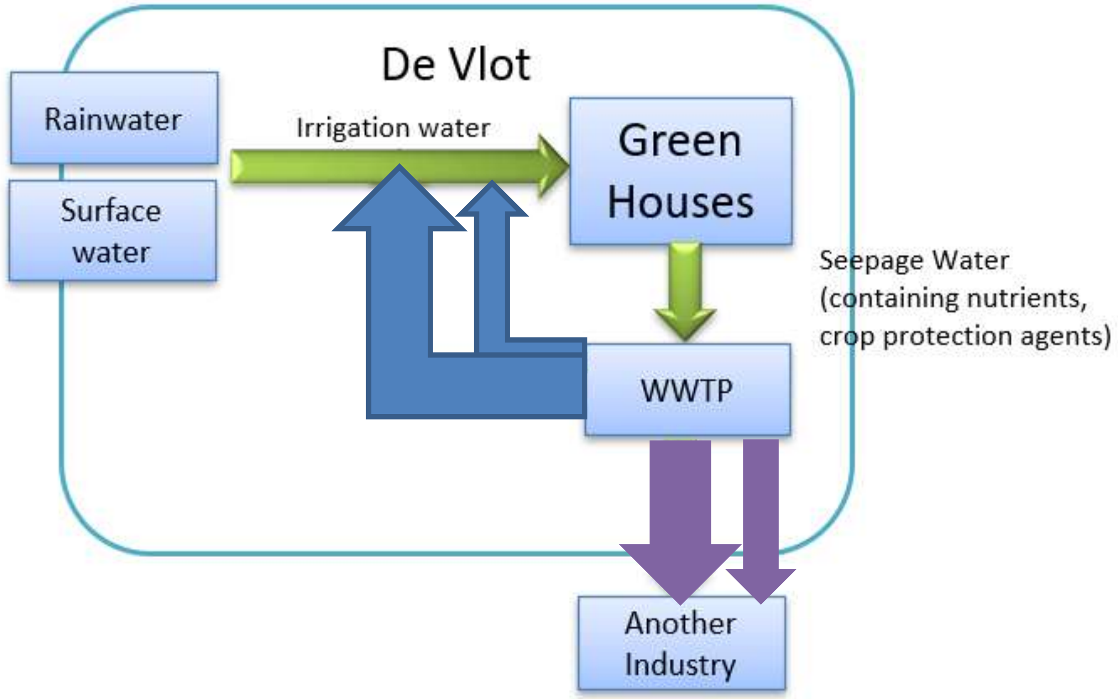
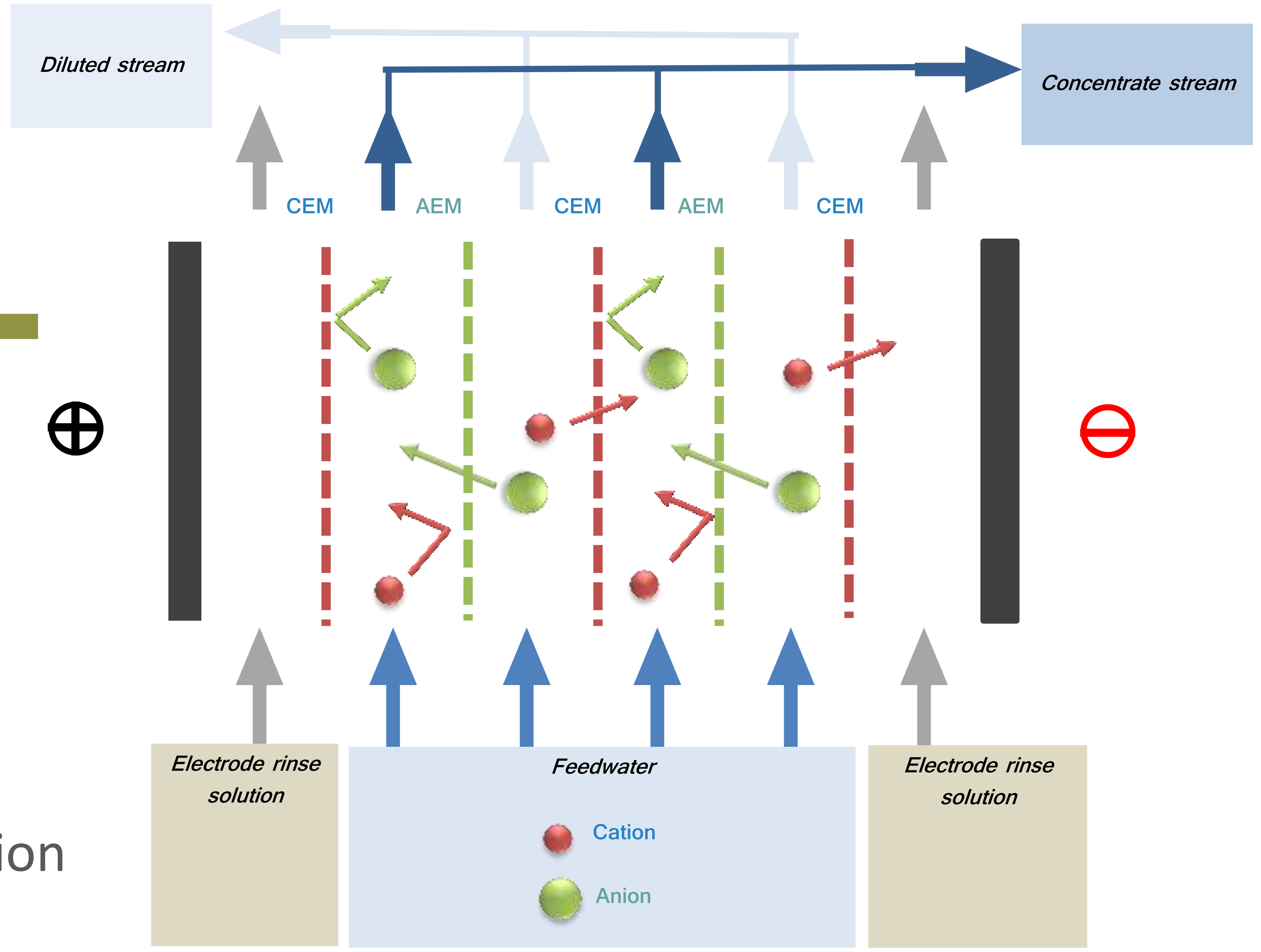
Status quo & proposed treatment

- Coöperatieve Tuinbouw Water Zuivering de Vlot
- 60 greenhouses (160 ha) with a collective treatment facility at a maximum capacity of 40-60 m3/h
- Currently, the treatment is linear with discharge into the sewer
- Proposed treatment is circular to enable irrigation water and fertilizer reuse (Sodium removal, Recovery/reuse of valuable fertilizers)



Electrodialysis



Why of ED (compared to SOTA)?

- Potential for ion-selective recovery
- Tunable production
  - Prevent sodium accumulation in effluent prior to recirculation
  - Ion concentration
  - Fits the needs of greenhouse horticulture

Challenges

- Process optimization for nutrient recovery

Source	NH_4^+ (mg/L)	K^+ (mg/L)	Na^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	NO_3^- (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	$H_2PO_4^-$ (mg/L)	EC mS/cm)	pH
De Vlot	2,16	73,70	162,09	195,74	52,21	215,52	271,21	211,90	3,95	1,9	7,3
Voogt 2009	8,51	273,7	138	320	85,06	1054,08	212,71	576,36	67,89	3	5,5

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Electrodialysis set-up

Main Parameters:

- 10 – 20 cell pairs (scalable)
- Membrane area 0.01 m2
- Fujifilm Type 10 IEMs
- Batch and one-pass

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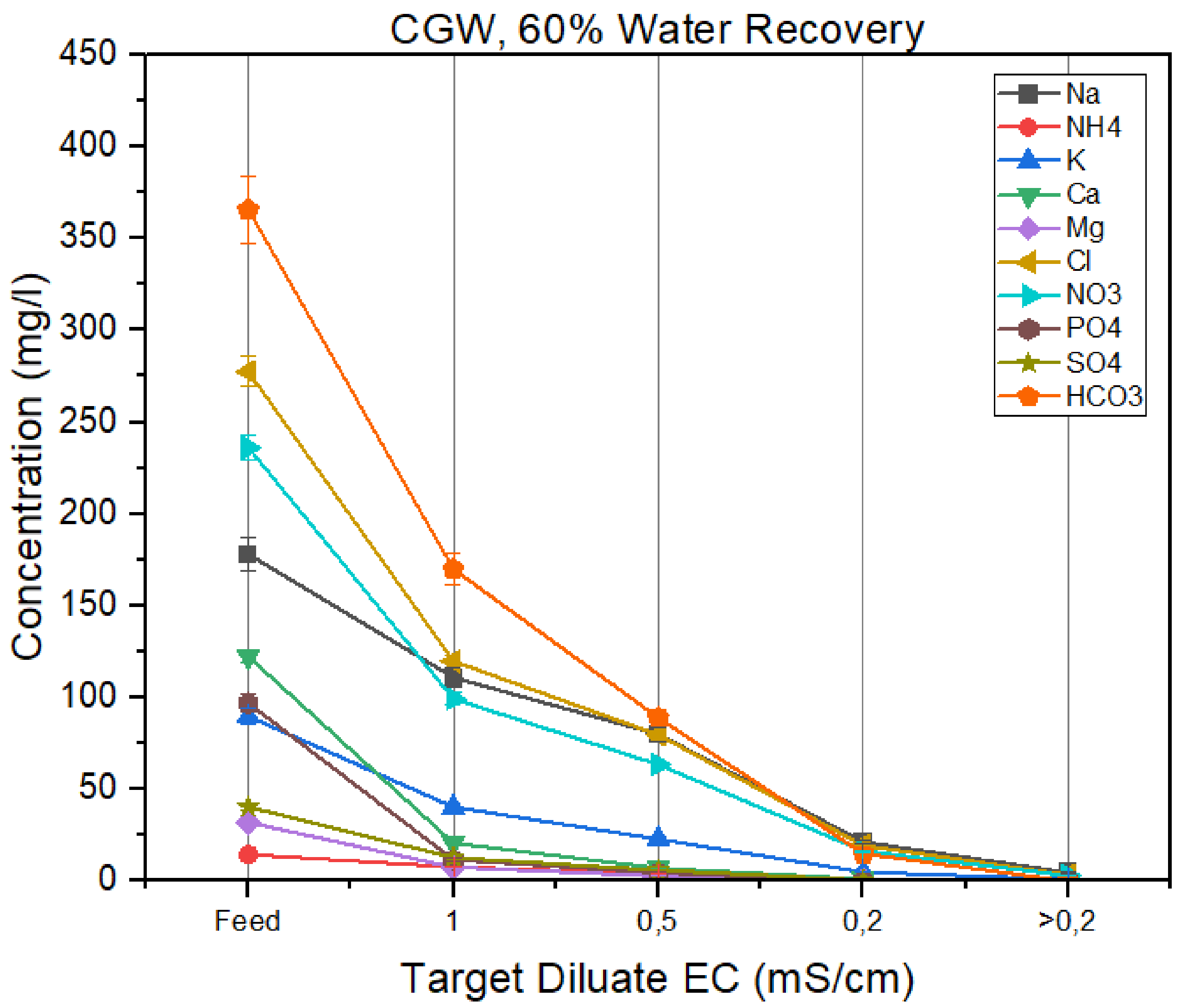
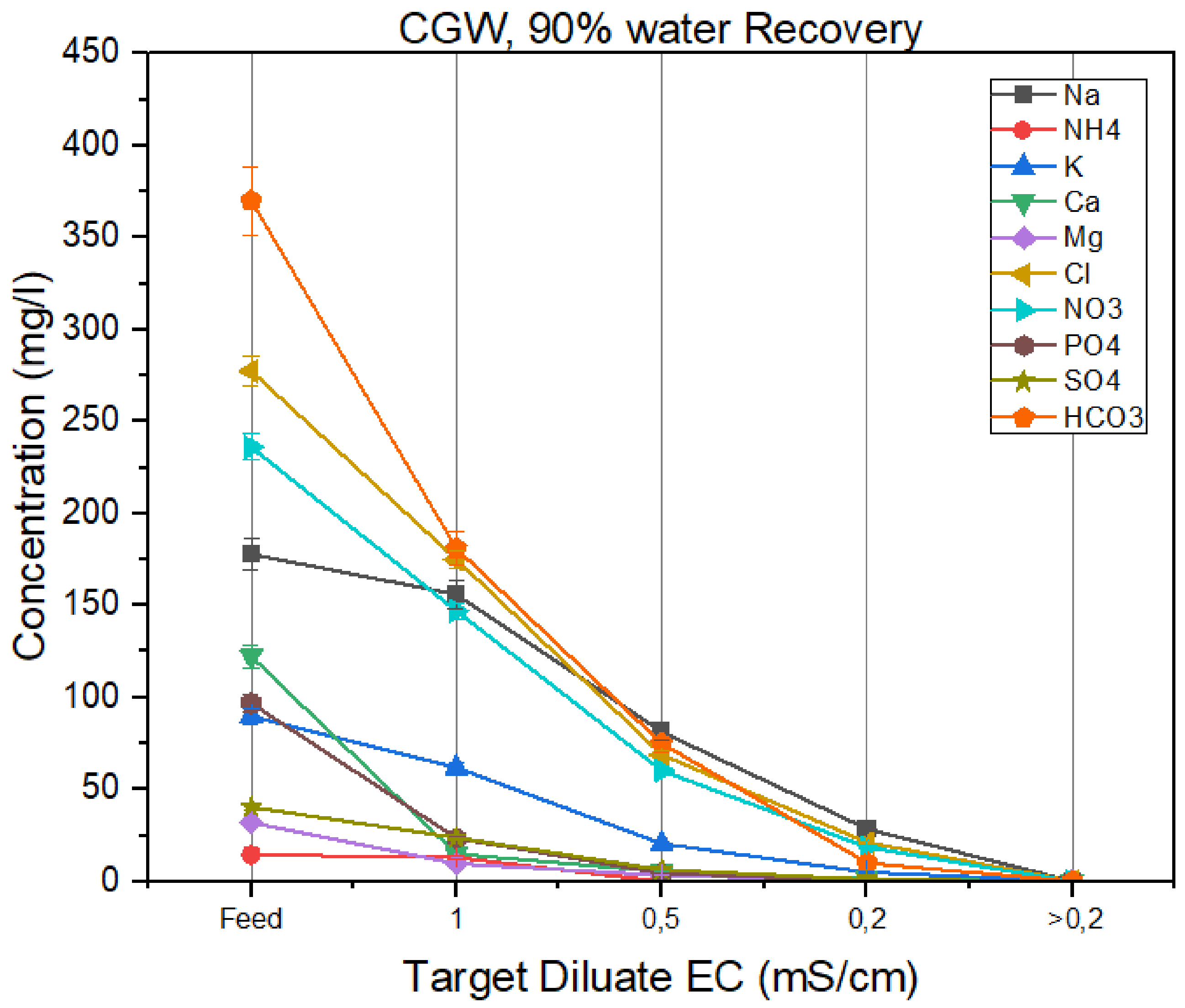
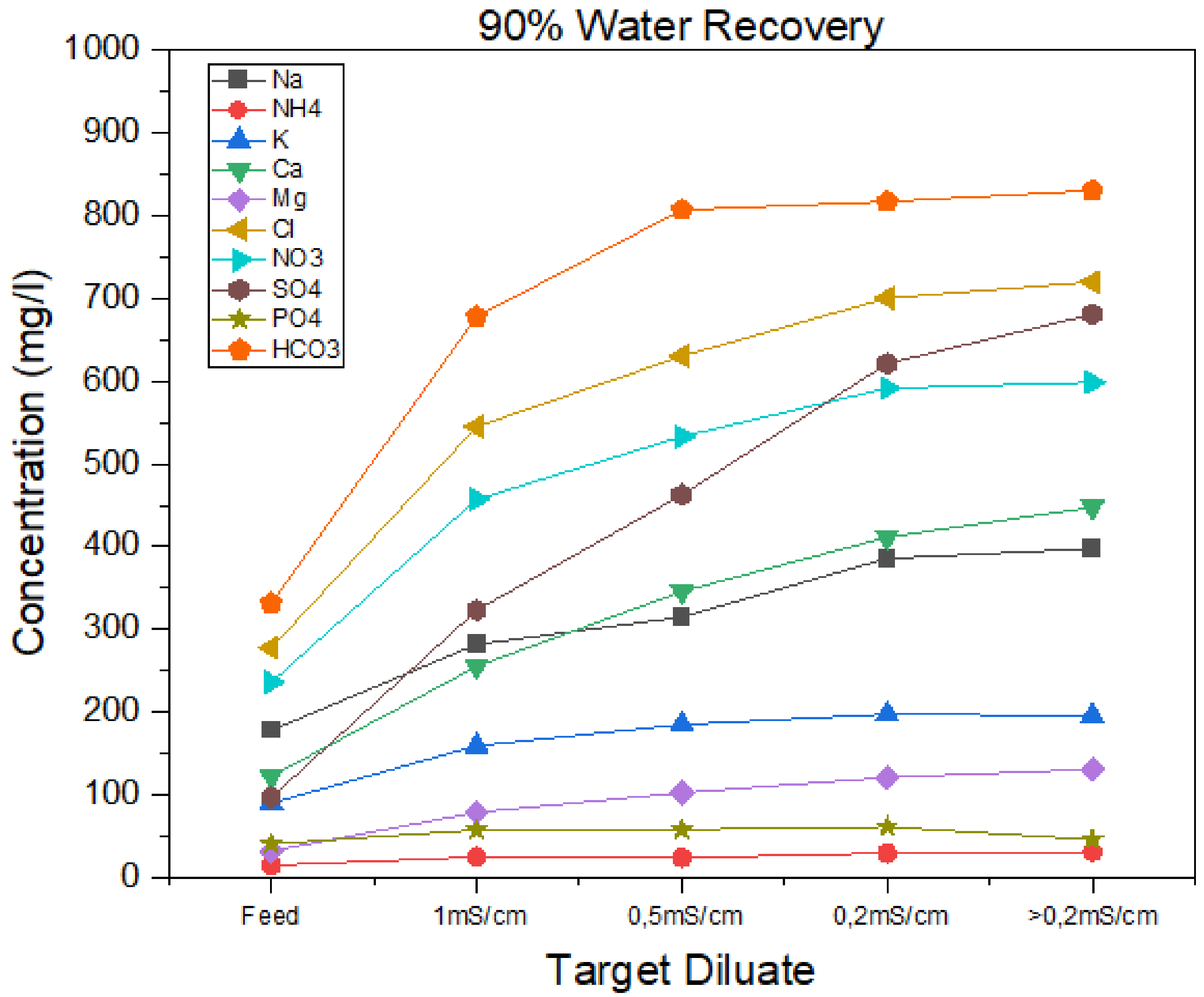
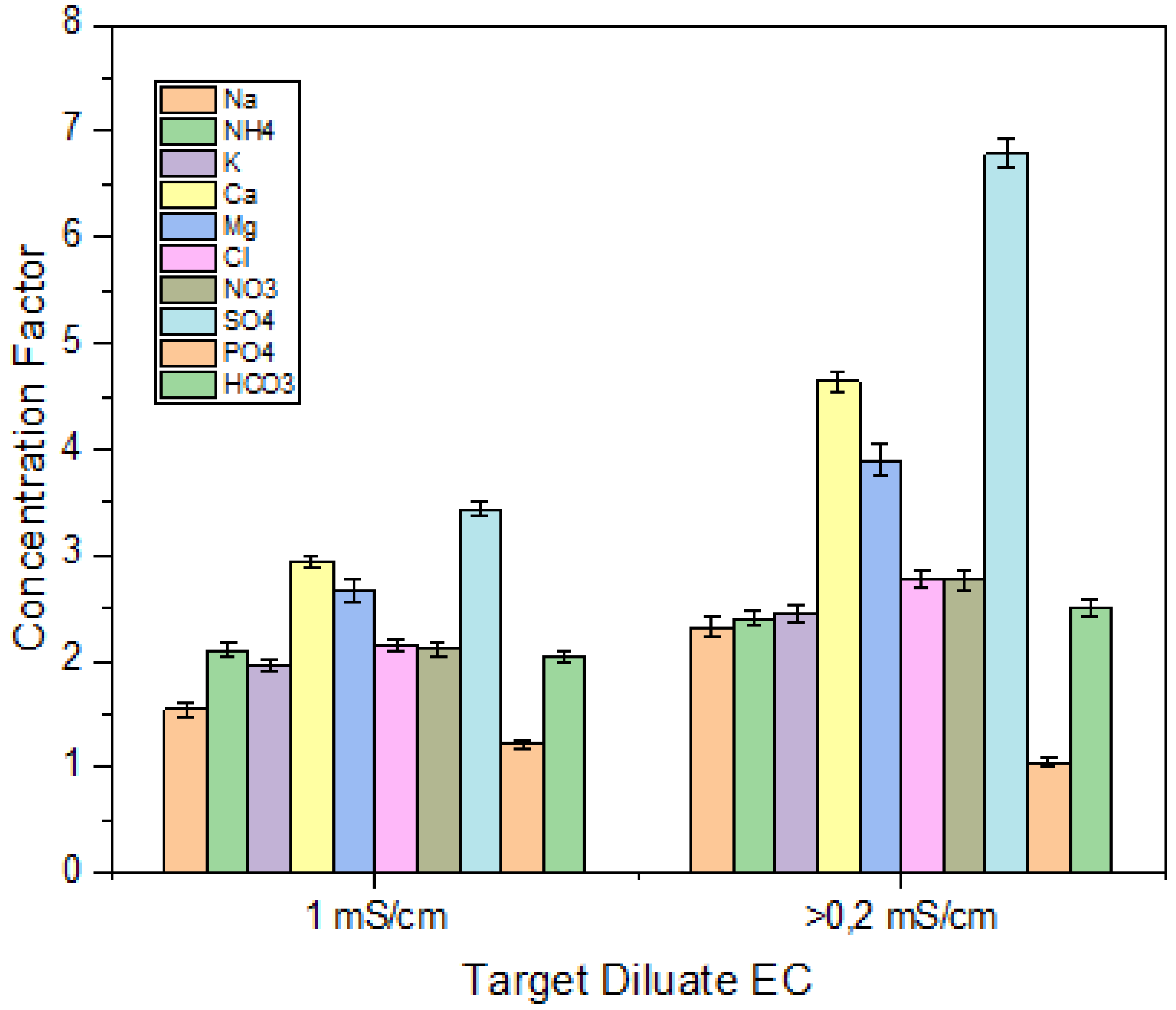
Initial Results – water recovery



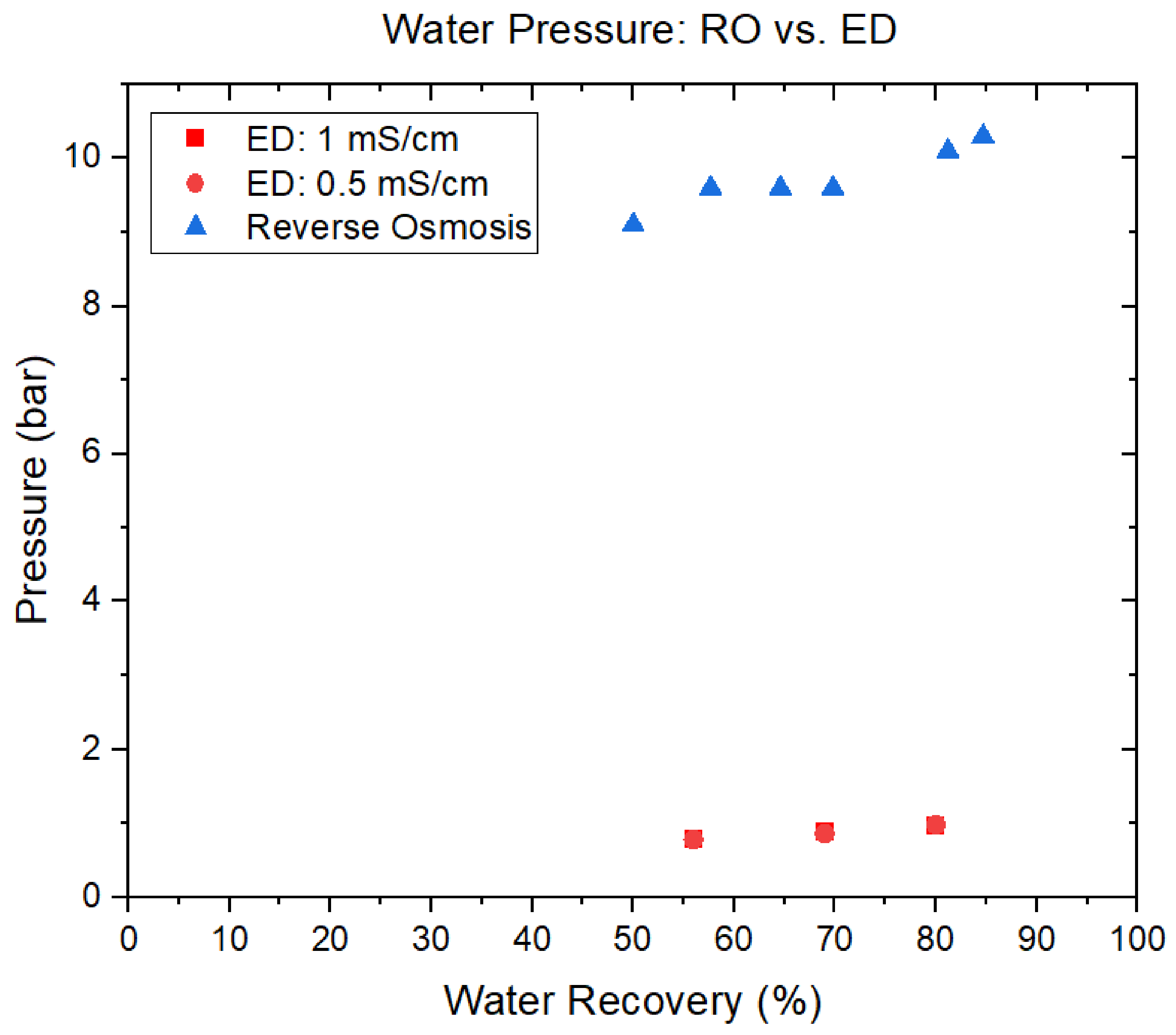


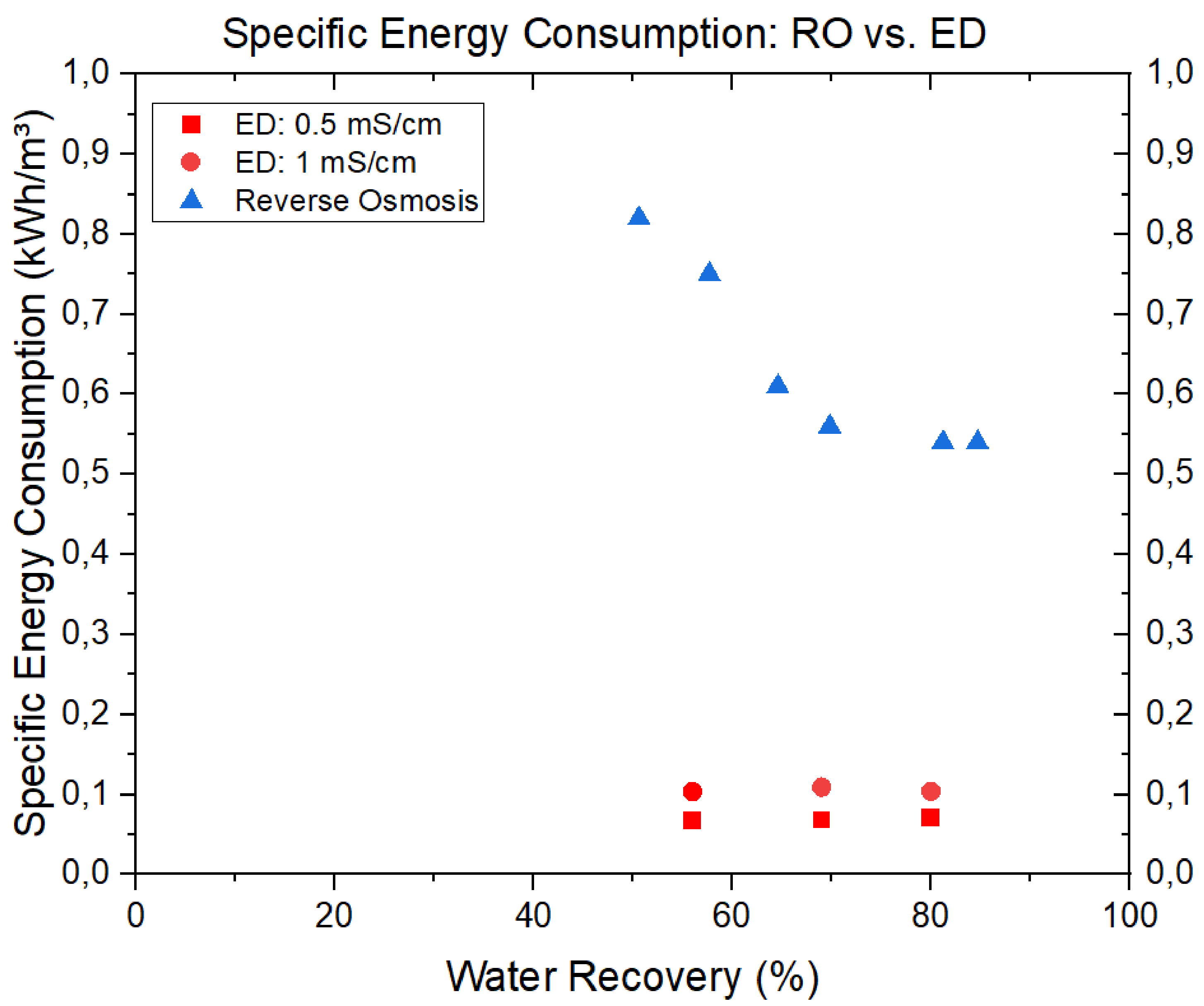
Initial Results – ions in concentrate





Comparison with RO (model results)





Conclusions

- The diluate produced had acceptable irrigation water quality for greenhouse application
- Specific energy consumption per m3 water recovered is ~ factor 6 lower than RO at feed quality in greenhouses
- Electrodialysis is an effective nutrient concentration technology
- Additional treatment steps needed for complete valorization
- Further selective separation from concentrated stream with additional technologies (e.g. mono-selective electrodialysis, ion exchange or donnan dialysis)

Next Steps

- Larger scale pilot
- Economic analysis (LCA)
- Microbiological Risk Assessment – what additional treatment is required for water reuse
- Increase selectivity of separation

Thank you!

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