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ZERO BRINE

Work Package 2

Re-designing the supply chain of water and minerals in the multi-company site of the Energy Port and Petrochemical cluster in Botlek area

H2020 project, June 2018

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Objective

- Demonstrate NF – Evaporation concept for the treatment of IX regenerates and their subsequent exploitation for regeneration of IX-resins (internal valorization)
- Demonstrate AIX – NF – Evaporation – EFC concept
- Combine waste heat and wastewater streams in a multi-company site environment with the aim to eliminate brine effluent of the industrial water supplier, to recover high purity magnesium and to recycle streams within the site

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Tasks

- 2.1: Preliminary design considerations (TU DELFT, NTUA, LENNTECH, EVIDES, UNIPA) [1-12]
  - 2.1.1: Determination of main brine treatment plant components for EVIDES SITE I [1, ~6]
  - 2.1.2: Determination of main components for EVIDES case II [7, ~6]
- 2.2: Design, manufacturing and installation of the demo plants (NTUA, LENNTECH, TU DELFT, UNIPA, ARVIA) [7-24, ~14]
  - 2.2.1: Final engineering design of the brine treatment systems for EVIDES Site I & II
  - 2.2.2: Manufacturing large demo and pilot system components (**TU DELFT**, LENNTECH, NTUA, UNIPA, ARVIA)
  - 2.2.3: Assembling and installation of the large demo and pilot plants at the site of EVIDES, in the Botlek area (**LENNTECH**, NTUA, UNIPA, EVIDES)
- 2.3: Operation, optimization and assessment of the large-scale demonstration plants (**EVIDES**, TU DELFT, NTUA, LENNTECH, ARVIA, UNIPA) [19-42]
- 2.4: Data collection from demo plants at EVIDES Site I and Site II – Input for WP1, WP7, WP8, WP9, WP10 (**TU DELFT**) [1-42]

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Deliverables

- D2.1 : Report on the results from the simulations using PHREEQC [6]
- D2.2 : Report on physicochemical analyses on the wastewater compositions [6]
- D2.3 : Report on the bench-scale tests using equipment from the BEC [10]
- D2.4 : Report explaining the design procedure [18]
- D2.5 : Detailed engineering drawings [18]
- D2.6 : Report on the operation and optimization process [42]
- D2.7 : Database of data collected during WP2 demonstration activity [6]

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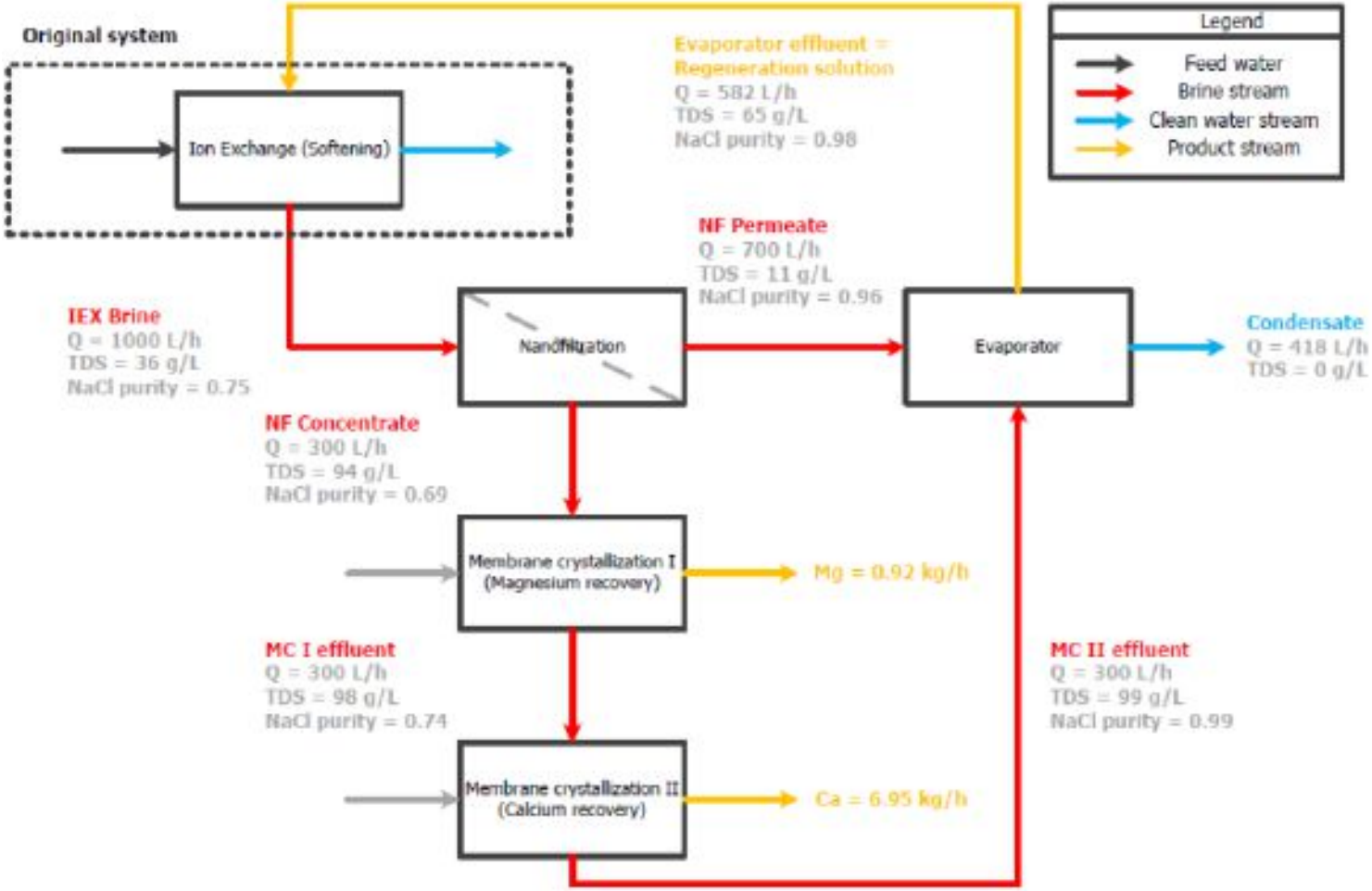
Pilot 1 Botlek



D2.1 PHREEQC

Composition of NF concentrates at 50% and 70% recovery

Elem. or ion	Sample 1				Sample 2			
	50% recovery		70% recovery		50% recovery		70% recovery	
	$mg.L^{-1}$	$mol.L^{-1}$	$mg.L^{-1}$	$mol.L^{-1}$	$mg.L^{-1}$	$mol.L^{-1}$	$mg.L^{-1}$	$mol.L^{-1}$
As^{5+}	0.03	3.6E-7	0.04	5.7E-7				
Ba^{2+}	0.85	6.2E-6	1.36	9.9E-6	0.42	3.0E-3	0.67	4.9E-6
B^{3+}	0.04	3.5E-6	0.06	5.6E-6				
Ca^{2+}	10 401.63	2.6E-1	16 565.57	4.1E-1	11 987.61	3.0E+2	19 091.38	4.8E-1
Cr^{3+}	0.02	4.5E-7	0.04	7.2E-7	0.29	5.6E-3	0.47	9.0E-6
Cu^{2+}	0.06	9.3E-7	0.09	1.5E-6				
Li^{+}	0.12	1.7E-5	0.13	1.9E-5	0.33	4.8E-2	0.35	5.1E-5
Mg^{2+}	2 122.20	8.7E-2	3 379.80	1.4E-1	1 791.00	7.4E+1	2 852.33	1.2E-1

….Etc.

Mg and Ca may be separated with great efficiency from spent IEX regenerant, however complete (> 99%) recovery not possible. Esp. part of the Mg will end up as scaling before reaching the crystallization step.

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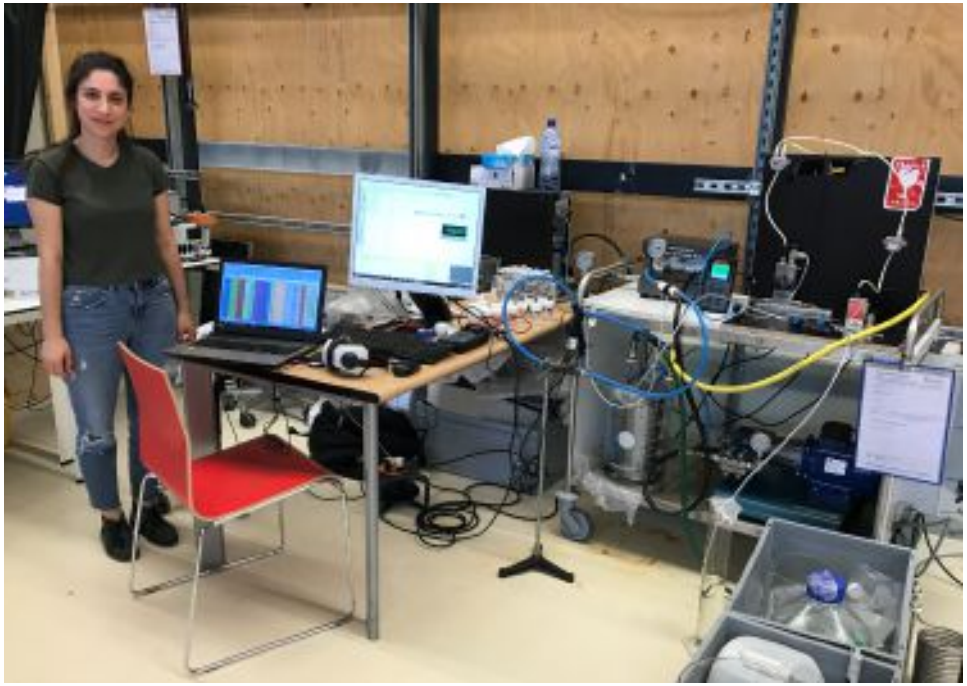
D2.2 Water analysis IEX regenerant

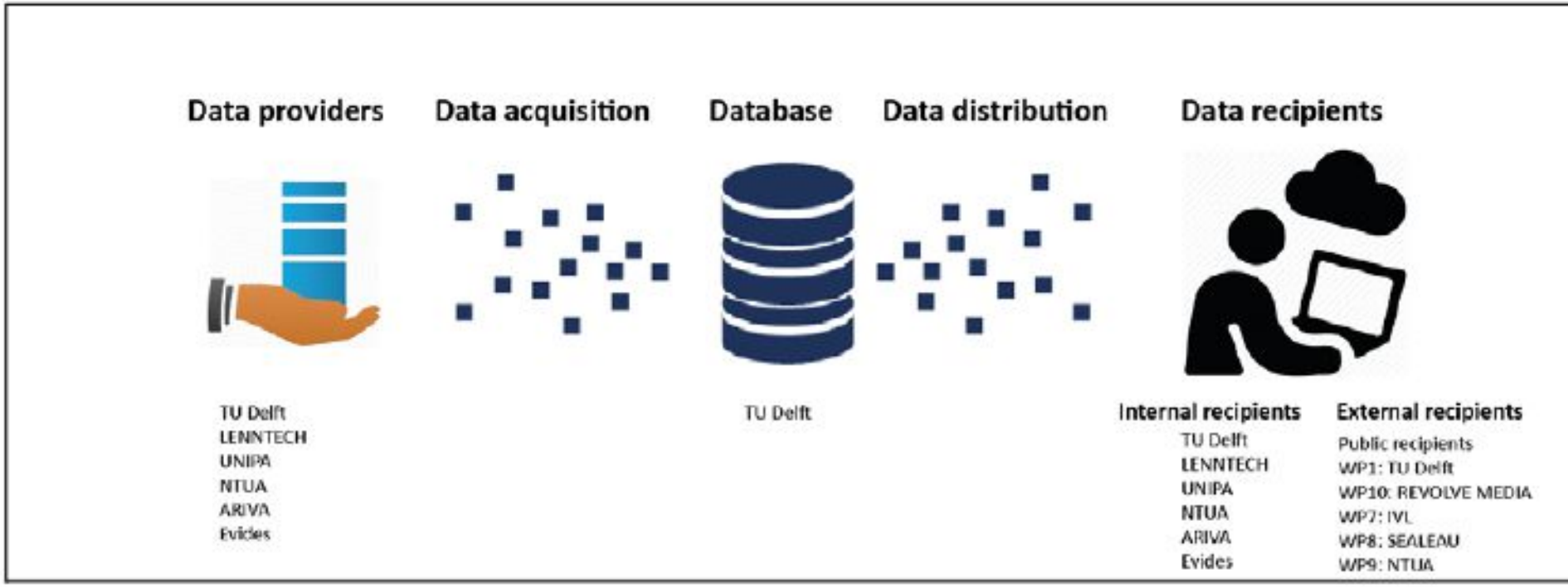
Cations		MW g/mol	Concentration mM	Anions		MW g/mol	Concentration mM
Sodium	Na^{+}	23.0	222.36 ± 201.63	Chloride	Cl^{-}	35.5	691.94
Magnesium	Mg^{2+}	24.3	44.81 ± 9.22	Fluoride	F^{-}	19.0	0.00
Potassium	K^{+}	39.1	4.95 ± 1.54	Bromide	Br^{-}	79.9	0.00
Calcium	Ca^{2+}	40.1	163.31 ± 0.79	Iodide	I^{-}	126.9	17.52
Iron	Fe^{3+}	55.8	0.02 ± 0.02	Nitrite	NO_2^{-}	46.0	0.00
Titanium	Ti^{2+}	47.9	0	Nitrate	NO_3^{-}	62.0	0.00
Vanadium	V^{5+}	50.9	3.18E-6 ± 2.16E-6	Phosphate	PO_4^{3-}	95.0	4.11
Chromium	Cr^{3+}	52.0	9.61E-7 ± 9.85E-7	Sulphate	SO_4^{2-}	96.1	0.00
Lithium	Li^{+}	6.9	1.78E-5 ± 9.36E-7	Silicate	SiO_4^{6-}	92.1	31.14
Beryllium	Be^{2+}	9.0	0	Bicarbonate	HCO_3^{-}	61.0	
Aluminum	Al^{3+}	27.0	0				
Manganese	Mn^{2+}	54.9	8.42E-8 ± 1.19E-7				
Cobalt	Co^{2+}	58.9	2.51E-7 ± 3.54E-7				
Nickel	Ni^{2+}	58.7	1.40E-5 ± 1.48E-5				
Copper	Cu^{2+}	63.5	2.69E-7 ± 3.80E-7				
Zinc	Zn^{2+}	65.4	7.91E-7 ± 1.12E-6				
Strontium	Sr^{2+}	87.6	3.53E-4 ± 8.77E-5				
Molybdenum	Mo^{4+}	95.9	8.36E-8 ± 9.95E-8				
Silver	Ag^{+}	107.9	1.16E-8 ± 1.59E-8				
Cadmium	Cd^{2+}	112.4	1.56E-9 ± 2.21E-9				
Antimony	Sb^{5+}	121.8	5.30E-8 ± 6.80E-8				
Barium	Ba^{2+}	137.3	2.85E-5 ± 3.77E-6				
Thallium	Tl^{3+}	208.4	1.25E-9 ± 1.77E-9				
Lead	Pb^{2+}	207.2	1.43E-7 ± 2.02E-7				
Total Dissolved Solids (TDS)			40 456.42	mg/L			

D2.3 Bench scale tests

- Ultra Filtration (Lenntech)
- Membrane Crystallization (UNIPA)
- Evaporation (NTUA)



D2.7 Database: providers, managers and data recipients




Cooling Tower Huntsman
Central WWTP
Evides DWP
Chemical Plant
Ducor Petrochemicals BV
Lucite International
Holland BV
Plant One
Merseyweg 10
Bertschi B.V
Theemsweg
Tydestraat
Chemical Plant
Climax Molybdenum
Arbo Unie Europoort
Lyondell Chemie
Nederland BV
EQIN
Google
Stork Safety &
Humberweg
Merseyweg
A15
Rozenburg-Centrum

Plant One, Botlek

- Brine by IBC bulk containers
- Waste heat: condensate