A novel Energy Recovery Device/RO test rig targeted to treat & recoup low industrial wastewater flows.

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WP3 - Dublin City University
Presentation Overview

- Background and Rationale
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- Test Rig Design – P&ID
- Innovative Energy Recovery Device
- Membrane Selection – Initial Results
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Background and Rationale

Water sources, treatment technologies and demand:

Available water sources:
- Seawater: 63%
- Brackishwater: 20%
- River water: 8%
- Wastewater: 5%
- Pure water: 4%

Desalination technology usage: Installed capacity:
- RO: 60%
- MSF: 27%
- MED: 8%
- ED: 3%
- Others: 2%

Water demand by sector:
- Agriculture: 70%
- Domestic: 10%
- Industry: 20%

Source: Adapted from www.desaldata.com
Source: Adapted from www.worldometers.info/water/
### Background and Rationale

<table>
<thead>
<tr>
<th>Water purification technology</th>
<th>Energy (kWh/m³)</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Brackish water RO (core process)</td>
<td>1</td>
<td>(Semiat 2008)</td>
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<tr>
<td>Seawater RO with Energy recovery (core process)</td>
<td>2.2 to 2.7</td>
<td>(Semiat 2008, Macedonio, Drioli 2010)</td>
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<td>Seawater RO (all auxiliary requirements)</td>
<td>5 to 7</td>
<td>(Blank, Tusel et al. 2007, Macedonio, Drioli 2010)</td>
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<td>MSF</td>
<td>16 to 20</td>
<td>(Darwish 2007, Mabrouk, Nafey et al. 2010)</td>
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<td>MSF (all auxiliary requirements)</td>
<td>38.5 to 125</td>
<td>(Blank, Tusel et al. 2007)</td>
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<td>MED</td>
<td>14</td>
<td>(Mabrouk, Nafey et al. 2010)</td>
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<tr>
<td>MED (all auxiliary requirements)</td>
<td>32 to 122.5</td>
<td>(Semiat 2008)</td>
</tr>
<tr>
<td>Ultra-Pure Water RO (all auxiliary requirements)</td>
<td>9.55 to 10.24</td>
<td>(Hu, Wu et al. 2008, SEMI 2005)</td>
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- In the 1970s: the specific energy consumption of seawater reverse osmosis (SWRO) ~ 20 kWh/m³ (MacHarg and Truby, 2004)
Energy recovery devices have been one of several factors leading to lower energy footprint reverse osmosis (RO)

Energy recovery devices include Pelton/Francis turbines; various pressure exchangers including the Energy Recovery™ PX pressure exchanger and Flowserve DWEER™

DWEER™ operating flows: 160 m³/h - 350 m³/h

Energy Recovery™ PX pressure exchanger operating flows: PX-30 reported as 4.5 to 6.81 m³/h

Is there a device available for relatively low flow rates and is this device economical?

Source: Energy Recovery™ Product catalogues
Project Overview - SaltGae

Saltgae.eu

- H2020-WATER-1b-2015
- €9.8 million in funding
- 36 months duration
- Holistic and resource efficient approach to industrial wastewater treatment for EC Food & Beverage Industry
- Focused on industries required to treat saline wastewaters e.g. canned fish, meat processing, pickled vegetables, leather tanneries and aquaculture

Wastewater from the Food & Beverage industry

- Wastewaters with high concentrations of biodegradable organic matter, suspended solids, nutrients (mainly nitrogen and phosphorus) and salt (concentrations up to 15%)

Sources: [environmentalleverage.com](http://www.environmentalleverage.com/industry/food%20and%20beverage/Food_%20Beverage.html)
Objectives of SaltGae:

- A techno-economically viable solution for the treatment of saline wastewaters

- Specifically considers three different production processes across three pilot plants:
  - Tannery Plant located in Slovenia (~40 g/l salinity)
  - Whey Plant located in Italy (~10 g/l salinity)
  - Aquaculture Plant located in Israel (~3 g/l salinity)

- SaltGae suite of technologies:
  - High Rate Algal Ponds (HRAPs) hosting synergistic mixtures of halotolerant bacteria and algae
  - Anaerobic digestion
  - Energy efficient desalination to treat HRAP effluents for reuse/recycling

- Valorisation of perceived waste products
SaltGae – WP3

- Mixed algae-bacteria cultures for saline wastewaters
- Algae culture production processes
- Optimisation for target locations and seasons

WP2: Valoration of Sludge
- Wastewater primary treatment process
- Wastewater pre-treatment and conditioning for Low BOD
- Wastewater pre-treatment and conditioning for High BOD
- AD Technology development & integration
- Digestate Fertiliser

WP3: Valoration of HRAP Effluents
- Pre-treatment and conditioning of HRAP effluents
- Electro dialysis desalination
- Reverse Osmosis desalination
- New Pumping System and Energy Recovery Device

WP4: Valoration of Algae Biomass
- Biomass Harvesting
- Biomass refinement
- Extraction of compounds
- Animal feed
- Platform chemicals, resins and edible coatings
- High value material fillers & pastes

WP5: HRAP Integration and Process Optimisation
- Technology integration and pilot scale test bed
- HRAP design, sensorisation and monitoring
- Optimisation of HRAP operations

WP6: Large Scale Demonstration Sites
- Demonstration site 1 (Slovenia)
- Demonstration site 2 (Italy)
- Demonstration site 3 (Israel)

WP7: Integrated Sustainability and Business Viability Assessment
- Techno-economic evaluation
- Life Cycle analysis
- ETV

WP8: Innovation Strategy
- Mobilise stakeholder platform
- Strategy and tools for awareness raising and communication
- Events and workshops to discuss challenges, propose solutions and create strategic roadmaps

WP9: Dissemination and Exploitation
- Dissemination and Exploitation Plan
- IP Management Plan
- Dissemination and Exploitation Activities

WP10: Project management
- Project Management Plan
- Financial Reporting
- EC Communication

Source: saltgae.eu
WP3: Valorisation of HRAP effluents
- Pre-treatment and conditioning of HRAP effluents
- Reverse osmosis incorporating novel energy recovery device
- Electrodialysis

Pilot Plant in Slovenia:

Tannery Wastewater Salinity: 40 g/l

Anaerobic digestion

HRAP

Low flow rate: 0.1 m3/h
Salinity: 10,000 mg/l

RO pre-treatment

Permeate Water

RO with novel ERD
Test Rig Design – P&ID Diagram

RO Test Rig with Novel ERD included:

Source: DCU
Innovative Energy Recovery Device

- Initial test rig for the pump/energy recovery device
- Reciprocating, positive displacement pump/ERD
- This innovative ERD is IP Protected and therefore cannot be discussed in detail as of yet

Source: saltgae.eu
Membrane Selection – Initial Results

Dow ROSA9.1 Software Calculations

In order for the new ERD to function optimally, we require sufficient brine line pressure and flow.
This involves a slight trade off between water quality and energy consumption.

What does this mean?
- Higher Energy Recovery from the new ERD for lower flow rates
- Minimum mixing between brine and feed water
- Innovative design minimises flow fluctuations
Test Rig Design – Solidworks Model

Source: DCU
Optimising Energy Efficiency

- Water treatment requirements, and the associated energy requirements to treat water/wastewater to designated standards, vary according to application.

- Typically, the energy requirements are a function of scale, technology, incoming water quality and product water quality requirements.

- The proposed SaltGae design results in a more tailored, combined RO/ERD solution for each given wastewater site which yields more suitable water qualities (due to RO) whilst maintaining a low overall energy consumption (due to ERDs).

![Water characteristics at each pilot plant](image)
Future Work

- Manufacture the RO test rig
- Automation & calibration of RO test rig & respective instrumentation
- Programming of RO test rig’s programmable logic control (PLC)
- Test programme for high pressure pump, ERD, incorporating RO
- Optimisation of overall system control strategy
- Once tested and optimised, deploy the system in Israel and Slovenia
- Design system suitable for telemetry for remote monitoring
Questions

Any Questions?
Thank you for listening!

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