INTEGRAL WATER MANAGEMENT IN THE PAPER INDUSTRY: A CASE STUDY

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Complutense University of Madrid

University Complutense of Madrid

Origin: 1293
Students: 74,292
Staff: 9,290
Budget: 523 millions €
Its activities are conducted in two lines: Fundamental Research and the Applied Research, in order to enhance the technical and scientific expertise of the industry. The Fundamental Research is devoted to the acquisition of new knowledge and the fundamental understanding of the phenomena taking place during pulp and papermaking. On the other hand, the Applied Research is devoted to the application of these knowledge to solve the needs of the industry and suppliers.

### SPANISH PAPER SECTOR

<table>
<thead>
<tr>
<th>Production (t/y)</th>
<th>Paper</th>
<th>Pulp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total 2017</td>
<td>6.217.800</td>
<td>1.699.500</td>
</tr>
<tr>
<td>Total 2011</td>
<td>6.202.600</td>
<td>1.976.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consumption (t/y)</th>
<th>Paper</th>
<th>Pulp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total 2017</td>
<td>6.802.900</td>
<td>1.876.900</td>
</tr>
<tr>
<td>Total 2011</td>
<td>6.427.700</td>
<td>1.770.500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collection</th>
<th>Utilisation</th>
<th>Collection rate</th>
<th>Utilisation rate</th>
<th>Recycling rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total 2017</td>
<td>4.560.100</td>
<td>5.020.000</td>
<td>67</td>
<td>80,7</td>
</tr>
<tr>
<td>Total 2011</td>
<td>4.722.500</td>
<td>5.093.800</td>
<td>73,5</td>
<td>82,1</td>
</tr>
</tbody>
</table>

Source: ASPAPEL, 2017
## Water Usage and Sources

<table>
<thead>
<tr>
<th>Water Capture per source</th>
<th>Million m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well</td>
<td>23</td>
</tr>
<tr>
<td>Surface Waters</td>
<td>70</td>
</tr>
<tr>
<td>Supply Net</td>
<td>12,5</td>
</tr>
<tr>
<td><strong>Recovered Water</strong></td>
<td><strong>3,5</strong></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>109</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Pulp</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total water usage (m³/t)</td>
<td>35,4</td>
<td>7,9</td>
</tr>
<tr>
<td>Effluent (m³/t)</td>
<td>29</td>
<td>7</td>
</tr>
</tbody>
</table>

## Waste Water Effluents

<table>
<thead>
<tr>
<th>Onsite Waste Water Treatments</th>
<th>% of Total</th>
<th>Effluent Quality</th>
<th>Kg/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>8</td>
<td>COD (pulp)</td>
<td>7,2</td>
</tr>
<tr>
<td>Primary + Secondary</td>
<td>75</td>
<td>COD (paper)</td>
<td>2,2</td>
</tr>
<tr>
<td>Primary + Secondary + Tertiary</td>
<td>17</td>
<td>TSS (pulp)</td>
<td>1,0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TSS (paper)</td>
<td>0,4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Waste Water effluents</th>
<th>Million m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivers and Lakes</td>
<td>34</td>
</tr>
<tr>
<td>Sea</td>
<td>36</td>
</tr>
<tr>
<td><strong>Urban Sewers</strong></td>
<td><strong>21</strong></td>
</tr>
<tr>
<td>Estuaries</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL WATER DISCHARGES</strong></td>
<td><strong>93</strong></td>
</tr>
</tbody>
</table>
**Fresh water reduction Drivers**

- Towards Closed water circuits
- Closure degree varies with grades
- 90% reduction of water consumption in 3 decades
  - Minimize water footprint of the paper industry
  - Water quality appropriate for type of use

![Diagram showing various factors affecting fresh water reduction]

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**World Population**

- Projected world population until 2100
- *EVERY 2.6 WEEKS THE POPULATION OF MELBOURNE*

![Image showing world population projection]

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*Source: United Nations Department of Economic and Social Affairs, Population Division. World Population Prospects, 2017 Revision. Produced by United Nations Department of Public Information*
Vision

- Water quality appropriate for type of use.
- Minimize water footprint.
- Industrial growth decoupled from resource consumption.
- Symbiotic approach integrating industrial, urban and rural resources

Minimum contribution to water stress
- Water quality appropriate for type of use.
- Minimize water footprint.
- Industrial growth decoupled from resource consumption.
- Symbiotic approach integrating industrial, urban and rural resources

Minimum contribution to water stress
Holmen Paper

1.745,000 t/y

<table>
<thead>
<tr>
<th>Mill</th>
<th>Production</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madrid</td>
<td>300,000 t/y</td>
<td>Newsprint, Salmon and Improved Newsprint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Braviken 760,000 t/y Newsprint, MF magazine,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>coloured newsprint, and telephone directory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>paper</td>
</tr>
</tbody>
</table>

| Hallsta  | 685,000 t/y| MF magazine, SC paper, book paper, and newsprint, View |
|          |            | 1.745,000 t/y                                       |

Product Weight g/m²

<table>
<thead>
<tr>
<th>Product</th>
<th>Weight g/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holmen News Coldset</td>
<td>40, 42, 45, 48,8</td>
</tr>
<tr>
<td>Holmen News Heatset</td>
<td>40, 42, 45, 48,8</td>
</tr>
<tr>
<td>Holmen News Flexo</td>
<td>45</td>
</tr>
<tr>
<td>Holmen News Salmon</td>
<td>42, 45</td>
</tr>
<tr>
<td>Holmen Plus 65</td>
<td>45*, 49, 52*</td>
</tr>
</tbody>
</table>
1. HIGH PRODUCTIVITY
- Formation
- Retention
- Drainage

Max. production
Without breaks
Minimum cost

WATER MANAGEMENT

2. HIGH QUALITY PRODUCTS
Opacity, brightness, strength, ....

Disolution
Precipitation

Fibre-Fibre
Fibre-aggregates
Fibre-Fines
DCM-DCM
Fines-DCM
DCM-Filler
Fibre-Filler
Fines-Filler
Filler-filler
Filler-Agregates

Water Quality- interactions
Sustainable water management

- Conservation 10-12%

Fresh water consumption

Time

### Loops Separation

**Effluent**

- **Loop I**
- **Loop II**
- **PM Loop**

**Counter-current flow**

\[
K_1 = \frac{\text{COD}_{\text{Effluent}}}{\text{COD}_{\text{Fresh Water}}} \quad \text{K1 \rightarrow Efficiency of fresh water use in the paper machine.} \quad >1
\]

\[
K_2 = \frac{\text{COD}_{\text{Effluent}}}{\text{COD}_{\text{Fresh Water}}} \quad \text{K2 \rightarrow Efficiency of loop separation} \quad >1
\]

\[
\frac{K_1}{K_2} = 1 \quad \text{Good counter-current flow}
\]

### Process optimization

**Consistencia a la salida de prensas II = 24%**

<table>
<thead>
<tr>
<th>DDOO (mg/L)</th>
<th>2000-3500</th>
<th>1500-2300</th>
<th>500-800</th>
</tr>
</thead>
</table>

**Consistencia a la salida de prensas II = 30%**

<table>
<thead>
<tr>
<th>DDOO (mg/L)</th>
<th>2000-3500</th>
<th>1500-2300</th>
<th>300-550</th>
</tr>
</thead>
</table>
Sustainable water management

Conservation 10-12%

Process optimization 25-30%

Fresh water consumption

Time

Monash Univ, 16 August 2018


Improved water management

Freshwater savings

Water treatment and recirculation

Advanced water treatment and recirculation

Analysis & optimisation of water circuits, water use and consumption
- Water loop separation
- Counter-current flow
- Decreased flow rate of freshwater consumers
- Freshwater substitution with re-use water
- Fresh water substitution by clarified water
- Cooling/steaming water re-use
- Sealing water in close circuit
- ECF/TCF bleaching
- Dry deinking
- Sollage prevention
- Efficient save-alls
- Adequate storage capacity
- Efficient broke system

Use of kidney techniques for the elimination of suspended solids
- Filtration
- Fresh water substitution with super clear filtrate
- Re-use of condensates from evaporation
- High consistency loops separation
- Washing process optimization (use of wash presses)

Substitution of fresh water by reclaimed water
- Use of kidney techniques for the elimination of dissolved substances
- Fresh water substitution with efficient purified water
- Closed water circuits
- Substitution of fresh water by reclaimed water

A. Blanco / C. Negro
**Process optimization**

- **Loop I**
- **Loop II**
- **PM Loop**

---

**Sustainable water management**

- Conservation: 10-12%
- Process optimization: 25-30%
- Internal treatments: UF: 12-15%

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Improve water management
A MUST!

COD mg/L
2000-3500
1500-2300
300-500

K1 = \frac{\text{COD in waste}}{\text{COD in water}}

K2 = \frac{\text{COD out process}}{\text{COD in water}}

Sustainable water management

Conservation 10-12%
Process optimization 25-30%
But... there is a limit!
A. Blanco / C. Negro


SECONDARY LOOP
Long circuit
White Waters II
Fiber Recovery and Water Clarification

PRIMARY LOOP
Short Circuit
White Waters I
Pulp Preparation

TERTIARY LOOP
Fresh Water
PAPER

QUATERNARY LOOP
Excess Water
Final Effluent
mWWTP

Use of kidney techniques for the elimination of dissolved substances
Fresh water substitution with effluent purified water
Closed water circuits
Substitution of fresh water by reclaimed water

Analysis & optimization of water circuits, water use and consumers
Elimination of losses
Reorganization of water circuits
Model-based evaluation of optimized measured
Trained staff
Monitoring of water quality and treatment systems
Optimization of water use according with quality needed
Stewardship programs

Water loop separation
Counter-current flow
Decreased flow rate of freshwater consumers
Freshwater-substitution with re-use water
Fresh water substitution by clarified water
Cooling/steaming water re-use
Sealing water in closed circuit
ECP/TCF bleaching
Dry debarking
Spillage prevention
Efficient save-alls
Adequate storage capacity
Efficient broke system

Use of kidney techniques for the elimination of suspended solids
Filtration
Fresh water substitution with super clear filtrate
Reuse of condensates from evaporation
High consistency loops separation
Washing process optimization (use of wash presses)
Fresh water uses

Freshwater: 7 m³/t
Recovered paper

Recovered paper

Dried sludge: (2%)

Evaporation: (12%)
Recycled paper

Showers: 60%
Chemicals: 14%
Boilers: 7%
Hydraulic sealing: 9%

Water uses & quality

Minimum quality required for showers

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness, mgCaCO₃/L</td>
<td>&lt;200</td>
</tr>
<tr>
<td>Alkalinity, mgCaCO₃/L</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Suspended solids (TSS), mg/L</td>
<td>&lt;5</td>
</tr>
<tr>
<td>COD, mg/L</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Conductivity, μS/cm</td>
<td>&lt;500</td>
</tr>
<tr>
<td>Iron, mg/L</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Aluminium, mg/L</td>
<td>0.1</td>
</tr>
<tr>
<td>Magnesium, mg/L</td>
<td>&lt;15</td>
</tr>
<tr>
<td>Chloride, mg/L</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Sulfates, mg/L</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Microorganisms, CFU/100mL</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

Deposits of CaCO₃
Deposits, biofilms, abrasion
Scaling, corrosion, odours
Aerosols
**Selection of technologies**

- **Absence of microorganisms at final consumption**
- **Removal of salts (<0.5 mS/cm) and microorganisms**
- **To ensure an optimal performance of RO (LSI<3)**
- **To reduce organic matter (fouling) and SO₄⁻ (legal limits)**

**Chlorine/Chloramines/UV**

**RO**

**MF/UF**

**BIOLOGICAL TREATMENT**


**LSI** = Langelier Saturation Index

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**Effluent reclamation**

- **Freshwater**
- **Gravity table**
- **DAF**
- **Anaerobic + aerobic**
- **Coagulation + softening + flocculation**

**COD**: 2200 - 3000 mg/L
**Sulphates**: 505 - 800 mg/L
**Si**: 170 - 220 mg/L

**Limit**: silica

**Limit**: concentrates

**RO**

**MF/UF**

**ALTERNATIVE**

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Performance of biological systems

**Anaerobic treatment**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Activated Sludge</th>
<th>MBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD, %</td>
<td>60 ± 12</td>
<td>64 ± 7</td>
</tr>
<tr>
<td>BOD₅, %</td>
<td>86 ± 12</td>
<td>95 ± 2</td>
</tr>
</tbody>
</table>

**Biogas profitability**

- 0,25 Nm³ biogas/m³ treated water
- 1,5 kW·h/m³ treated water

**Aerobic treatment**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Activated Sludge</th>
<th>MBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD, %</td>
<td>45 ± 8</td>
<td>54 ± 8</td>
</tr>
<tr>
<td>BOD₅, %</td>
<td>72 ± 11</td>
<td>68 ± 9</td>
</tr>
<tr>
<td>SO₄²⁻, %</td>
<td>28 ± 16</td>
<td>30 ± 16</td>
</tr>
</tbody>
</table>

**Effluent quality:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ACTIVATED SLUDGE</th>
<th>MBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7,91</td>
<td>7,82</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>315</td>
<td>0</td>
</tr>
<tr>
<td>dCOD, mg/L</td>
<td>450</td>
<td>374</td>
</tr>
<tr>
<td>BOD₅, mg/L</td>
<td>43</td>
<td>17</td>
</tr>
<tr>
<td>SO₄²⁻, mg/L</td>
<td>383</td>
<td>333</td>
</tr>
</tbody>
</table>

**Irreversible fouling**

Hollow fibre membranes with fibre deposits

**Reverse osmosis**

SILICA IS A LIMITATION FOR RO

**Permeate**

- Excellent quality to substitute fresh water
- Recovery of 20% → Limitation

**Concentrate**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>VALUES</th>
<th>LAW</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>Conductivity, mS/cm</td>
<td>9,1</td>
<td>7,5</td>
</tr>
<tr>
<td>tCOD, mg/L</td>
<td>2365</td>
<td>1750</td>
</tr>
</tbody>
</table>

Monash Univ, 16 August 2018
Treatment of RO concentrates

Optimum coagulant: PAC  Dose (2-2.5-3 g/L)
Lime softening: pH (8, 9,5 y 10,5)
Flocculation
- Flocculant type (aPAM, cPAM)
- Dose (3-5-7 g/L)

<table>
<thead>
<tr>
<th>Coagulant (mg/L)</th>
<th>Lime (pH)</th>
<th>Floculant (mg/L)</th>
<th>COD removal (%)</th>
<th>Conductivity removal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 PAC</td>
<td>NO</td>
<td>NO</td>
<td>30</td>
<td>+10%</td>
</tr>
<tr>
<td></td>
<td>NO</td>
<td>5 (aPAM)</td>
<td>40</td>
<td>+30%</td>
</tr>
<tr>
<td></td>
<td>9.5</td>
<td>3 (aPAM)</td>
<td>60</td>
<td>+45%</td>
</tr>
<tr>
<td></td>
<td>9.5</td>
<td>5 (aPAM)</td>
<td>60</td>
<td>=</td>
</tr>
<tr>
<td></td>
<td>10.5</td>
<td>5 (aPAM)</td>
<td>60</td>
<td>=</td>
</tr>
</tbody>
</table>

Mill effluent treatment and reuse

- Water recovery in RO units is limited by silica
  - 20-40% RO recovery → Anaerobic + MBR + RO
  - 80% RO recovery if silica is removed  Limitation

- MBR permeate can be reuse
  - √ Showers and preparation of some chemicals
  - X Not suitable to prepare cPAM-bentonite retention system due to its anionic nature which reduce their efficiency  Limitation

- Important fresh water savings can be achieved
- There is a limit: 1.5-2 m³/t still necessary

This solution is not sustainable in water stress areas!
TERTIARY LOOP

SECONDARY LOOP

PRIMARY LOOP

Pilot Plants (1.5 m³/h)

Pilot plant trials during 3 months at Cuenca Media-Alta of Arroyo Culebro mWWTP
Pre-treatments performance

![Graph showing COD, Fe, and TMP over time]

- **Tertiary treated water**

Reverse osmosis performance

![Graph showing Flux and TMP over time]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>RO-1</th>
<th>RO-2</th>
<th>RO-3</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity, µS/cm</td>
<td>12</td>
<td>9</td>
<td>11</td>
<td>&lt;500</td>
</tr>
<tr>
<td>tCOD, mg/L</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>&lt;5</td>
</tr>
<tr>
<td>SO₄, mg/L</td>
<td>&lt;3</td>
<td>&lt;3</td>
<td>&lt;3</td>
<td>&lt;100</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>&lt;2</td>
<td>&lt;2</td>
<td>&lt;2</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Hardness, mg/L</td>
<td>&lt;7</td>
<td>&lt;7</td>
<td>&lt;7</td>
<td>&lt;200</td>
</tr>
<tr>
<td>NO₃, mg/L</td>
<td>0.69</td>
<td>0.23</td>
<td>0.24</td>
<td>&lt;1</td>
</tr>
<tr>
<td>P, mg/L</td>
<td>0.07</td>
<td>0.06</td>
<td>0.06</td>
<td>&lt;0.2</td>
</tr>
</tbody>
</table>

- **Membrane change in RO-2.**
- **Chloramines addition in this line.**
- **Uncontrolled dumping of free chlorine within the tertiary treatment** → increased flux & did not oxidized the membrane.

*Ordoñez R et al. CEJ, 2010*
In 2012 CYII built a WWRP, based on this multi-barrier membrane system, to supply Holmen Paper Madrid with reclaimed water instead of drinking water.

Limits/barriers:
- Quality of the municipal waste water effluent
- Legislation
- Acceptation
- Water price
Sustainable Process-Water-Product Management

Where are you? m³/t = ??

Closure has consequences → Problems?
Process change with time → Optimised water circuit?
Reduced maintenance costs → Water effects?

Where do you want to be? m³/t = ??
Driven force?

Fresh water consumption

DF ✔ DF
Closure limits

Fresh water costs

Long term losses
Discharge costs
Loss of opportunities
Total costs

Problem 1
Problem 2
Problem 3

Chemicals costs

Product 1 g/L | mg/L COD
---|---
Starch | 100/1200
Sizing | 1250-2800
CMC | 840-1400
Defoamers | 1700-2900

Sustainable Process-Water-Product Management

Water audit
- Water quality
- Problems
Mapping: pH, λ, COD, ...
- Critical contaminants/areas
- Sources of problems
- Critical operation conditions
Water capacity
Water reuse: \( K_1 \), \( Q_{water}/Q_{wastewater} \)
Counter-current flow: \( K_1/K_2 \)
Loop separation: \( K_2 \)
Water fit for use
WWTP efficiency
Chemical treatments
Loss of opportunities
Benchmarking
- Improvement opportunities

Awareness
- Integral P-W-P management
- Prevention is key
- Training program: new procedures
Monitoring water quality: checking day list
- Low retention time: 2-3h
- Optimize water treatment
- Chemical treatments
- Improve treatments efficiency: DAF
Maintaining water quality
- Operation conditions P-W-P
- Maintenance program
- Avoid anaerobic condition
Water quality use/quality needed
- Identify domino effects
- Reorganization of circuits?
- Separation of loops
- Thickeners?
Internal treatments
- Kidneys?
- Effluent treatment and reuse?
- Model-based evaluations?

Knowledge
Critical water issues
Goals

Prioritized list of actions
Housekeeping
Chemistry $$$
Investments $$$$
Kidney technologies

Modification of pH \(\rightarrow\) Conductivity!

- pH = 8.6 and 2500 mg/L PACl5 \(\rightarrow\) 60%
- RO recovery \(\sim\) 40%

Silica maybe a limitation in deinking plants!

- Viable RO \(\rightarrow\) >80% recovery
- Silica removal > 85%

Modification of pH \(\rightarrow\) Conductivity!

- pH = 8.6 and 2500 mg/L PACl5 \(\rightarrow\) 60%
- RO recovery \(\sim\) 40%

Silica maybe a limitation in deinking plants!
TREATMENT SELECTION

Characteristics of the treatments to achieve high silica removal rates (>90%) for the treatment of high silica content (150-200 mg/L) and low hardness waters (2-7 mg/L)

<table>
<thead>
<tr>
<th>ADDITIVE</th>
<th>COAGULATION</th>
<th>SILICA REMOVAL DURING PRECIPITATIVE SOFTENING</th>
<th>ADSORPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYBRID COAGULANT (PANS‐PA2)</td>
<td>Soluble Mg compounds (MgCl₂·6H₂O)</td>
<td>Sparingly soluble Mg compounds (MgO)</td>
<td>Calcined hydrotalcite</td>
</tr>
<tr>
<td>TEMPERATURE</td>
<td>25°C</td>
<td>25°C</td>
<td>≥ 35°C</td>
</tr>
<tr>
<td>pH</td>
<td>10.5</td>
<td>11.5</td>
<td>8.5</td>
</tr>
<tr>
<td>DOSAGE</td>
<td>2500 mg/L</td>
<td>1500 mg/L</td>
<td>500 mg/L</td>
</tr>
<tr>
<td>COD REMOVAL</td>
<td>↑↑</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FINAL CONDUCTIVITY</td>
<td>↑↑</td>
<td>↑↑↑</td>
<td>↑</td>
</tr>
<tr>
<td>SLUDGE GENERATION</td>
<td>↑↑</td>
<td>↑↑↑</td>
<td>↑↑</td>
</tr>
<tr>
<td>COST</td>
<td>↑↑↑</td>
<td>↑↑</td>
<td>↑</td>
</tr>
</tbody>
</table>

Monash Univ, 16 August 2018
CONCLUSIONS

• How far can we go?
  • Board/packaging 0-3 m³/t
  • Liner 0-3.5 m³/t
  • Graphic paper 6-15 m³/t  100% Reclaimed water
  • Tissue 6-12 m³/t

• Optimal SWM = SPWPM ➔ Global approach but local solutions
• Look outside your fence!
• Pre-treatments are essential and cheaper
• Limits are further that what we expect
• R&D studies focus
  • Concentrates
  • Scaling / Fouling
  • Energy

• Post-treatments are available if needed
• Barriers: legal, acceptation
• Costs