Wastewater reuse for industrial applications in cooling towers

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Tarragona Region

- Tarragona is a seasonal water stressed region that uses Ebro River water for Municipal and Industrial applications
- Industrial Water Rights are mainly used in Cooling Towers inside Petrochemical Complex

Municipal Water Rights (%)
- Water consumption: 85.8%
- Grant not used: 14.2%

Industrial Water Rights (%)
- Water consumption: 53.1%
- Grant not used: 46.9%
Camp de Tarragona Advanced Water Reclamation Plant

- Reclamation Plant is designed for 19,000 m$^3$/d of permeate water from Tarragona and Vila-seca Wastewater Treatment Plant. It is owned by ACA and operated by Veolia and AITASA.
- Reused water is blended with Ebro River water in order to provide make-up cooling water for the Tarragona Petrochemical Complex Plants.
Camp de Tarragona Advanced Water Reclamation Plant

- Pretreatment consist of Veolia Actiflo technology
- First pass uses DOW FILMTEC™ BW30XFR-400/34i extra fouling resistant membranes
- Second pass uses DOW FILMTEC™ LE-440i low energy membranes
Wastewater Reuse Strategy

- Pipe is built to blend RO permeate with Ebro river water and provide make-up water to North petrochemical production complex (Ethylene Cracker) in La Pobla de Mafumet (Tarragona). Current blending ratio is 40% reclaimed water, aiming to 90%

- Pipe is being build to blend RO permeate with Ebro river water and provide make-up water to South production complex (Poliolefins and Polyols/Polyglycols Plants)
Reverse Osmosis Permeate vs River Water

- Reverse Osmosis permeate offers superior and more stable quality
- A water demineralization is available to supply 30 m³/h of highly demineralized water (0.2 µS/cm) to the petrochemical park
Reverse Osmosis Permeate vs River Water

- Reverse Osmosis permeate offers superior and more stable quality.
- This allows increasing Cooling Tower concentration cycles from 4 to 7 without increasing scaling or corrosion tendency.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Ebro River</th>
<th>RO Permeate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity (µS/cm)</td>
<td>950</td>
<td>19</td>
</tr>
<tr>
<td>Cl (mg/L)</td>
<td>95</td>
<td>2.9</td>
</tr>
<tr>
<td>CaCO₃ (mg/L)</td>
<td>260</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>SO₄ (mg/L)</td>
<td>160</td>
<td>0.02</td>
</tr>
<tr>
<td>NH₃ (mg/L)</td>
<td>0.1</td>
<td>&lt; 0.8</td>
</tr>
<tr>
<td>PO₄ (mg/L)</td>
<td>0.1</td>
<td>&lt; 0.002</td>
</tr>
<tr>
<td>TOC (mg/L)</td>
<td>1.2</td>
<td>&lt; 0.3</td>
</tr>
</tbody>
</table>
Main Challenges for Reused Water

Highly corrosive water
- Mild steel corrosion due to lack of buffer capacity in the presence of Cl and oxygen
- Low calcium prevents normal corrosion inhibition mechanisms
- Copper corrosion due to ammonia

Microbial activity
- Microbiological growth due to high nutrients and organic content
- Chloramine formation lowering biocide activity

Highly variable make up water
- High cycles possible due to low salt content
- Cycles limited by leaks, upsets, etc. (quick variation in cycles with a leak)
Reclaimed Water Phases

- The Reverse Osmosis make-up water presented 3 phases:
  - Initial step is between 40-60 m³/h (15%)
  - Then moves up to 100 m³/h (25%)
  - Finally reach 160 m³/h (40%)
Cooling Towers Concentration Cycles

- The Cracker cooling tower ran on 100% Ebro river water at 4 cycles prior to the gradual change to 160 m³/h of RO permeate at 7 cycles.

- Increase in concentration cycles during high municipal demand during summer due to higher evaporation reduces consumed water by 110 m³/h (22%) and a sewage reduction of 76 m³/h (49%).

<table>
<thead>
<tr>
<th>Compound</th>
<th>Ebro (mg/L)</th>
<th>RO Permeate (mg/L)</th>
<th>Ebro x 4 (mg/L)</th>
<th>Permeate x 7 (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity (µS/cm)</td>
<td>950</td>
<td>19</td>
<td>3,800</td>
<td>135</td>
</tr>
<tr>
<td>Cl (mg/L)</td>
<td>260</td>
<td>2.9</td>
<td>1,040</td>
<td>21</td>
</tr>
<tr>
<td>CaCO₃ (mg/L)</td>
<td>95</td>
<td>&lt; 0.1</td>
<td>380</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>SO₄ (mg/L)</td>
<td>160</td>
<td>0.02</td>
<td>640</td>
<td>0.07</td>
</tr>
<tr>
<td>NH₃ (mg/L)</td>
<td>0.1</td>
<td>&lt; 0.8</td>
<td>0.4</td>
<td>&lt; 5.0</td>
</tr>
<tr>
<td>PO₄ (mg/L)</td>
<td>0.1</td>
<td>&lt; 0.002</td>
<td>0.4</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>TOC (mg/L)</td>
<td>1.2</td>
<td>&lt; 0.3</td>
<td>4.8</td>
<td>&lt; 2.0</td>
</tr>
</tbody>
</table>
Corrosion Study

- Nalco Champion 3D TRASAR® Technology allows to run at higher cycles of concentration without affecting corrosion and scaling.
- Carbon Steel and Copper-Nickel corrosion is not affected by using Reverse Osmosis permeate water as both are kept negligible (<1 mpy and < 0.1 mpy respectively).
Microbiological Study

- Reverse Osmosis Permeate is a safe water
- Ammonia is just found in traces levels
- Total Organic Carbon (TOC) is below recommended limit of 50 ppm
- Aerobic Bacteria are below recommended range of < 10,000 UFC/mL
- Legionella concentration is below minimum range of 40 UFC/ml

<table>
<thead>
<tr>
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<th>River Water (100%)</th>
<th>River Water (60%) + Reclaimed Water (40%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling Water NH3 (mg/L)</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Cooling Water TOC (mg/L)</td>
<td>19.3</td>
<td>21.0</td>
</tr>
</tbody>
</table>
Key Takeaways

- Reclaimed water can be used in the industry instead of pre-treated river water with a positive impact in the environment as it does not hydraulically stressing rivers.

- Stable operation of the cooling tower is achieved since starting blending reclaimed water as make-up water in the Dow Tarragona Ethylene Cracker Cooling Tower.

- Reclaimed water is used up to 160 m³/h (40%). Depending on the season this frees up more than 200 m³/h of water rights for the municipality. Cooling Tower Blowdown discharge is reduced by 76 m³/h (49%).

- Nalco Champion 3D TRASAR® Technology allows to run at higher cycles of concentration without affecting corrosion.

- Using reclaimed water from a Wastewater Treatment plant that has undergo a Reverse Osmosis filtration step present no health concerns when compared with conventional pre-treated river water.
This project is framed under the European Research and Development funded DEMOWARE Consortium, led by CTM (Centre Tecnològic de Manresa), under the FP7-ENV-2013-WATER-INNO-DEMO Call.

Thank You

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