

Wastewater reuse for industrial applications in cooling towers

Tuesday 3rd November 2015

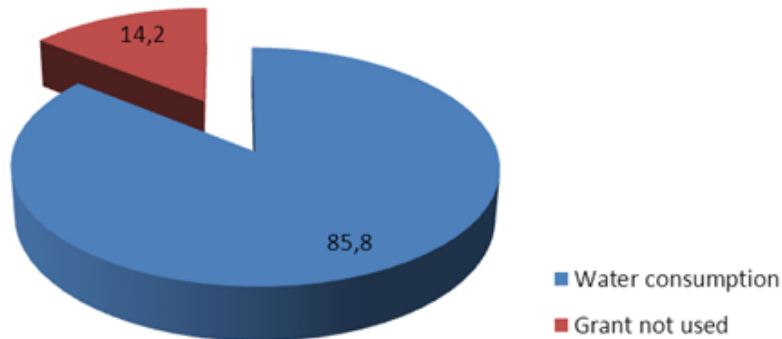
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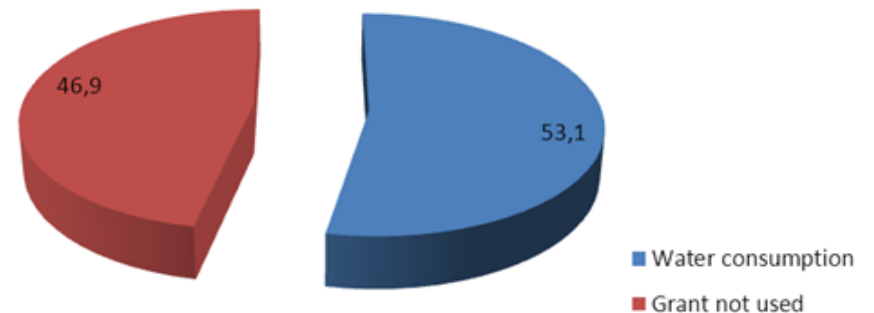
Tarragona Region

- 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 (%)

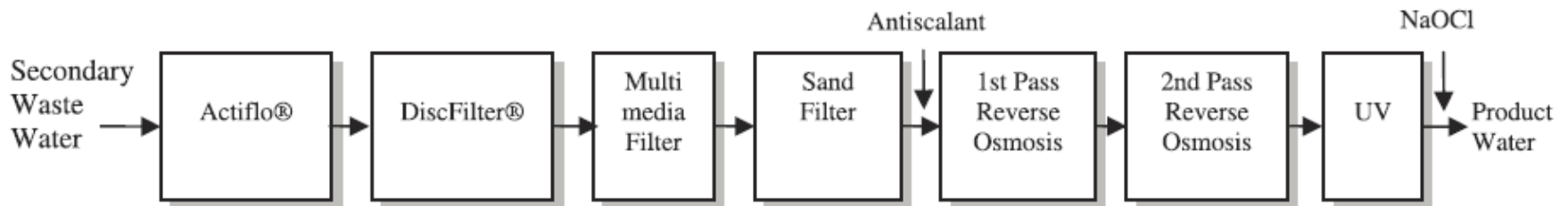


Industrial Water Rights (%)



Camp de Tarragona Advanced Water Reclamation Plant

- Reclamation Plant is designed for 19,000 m³/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



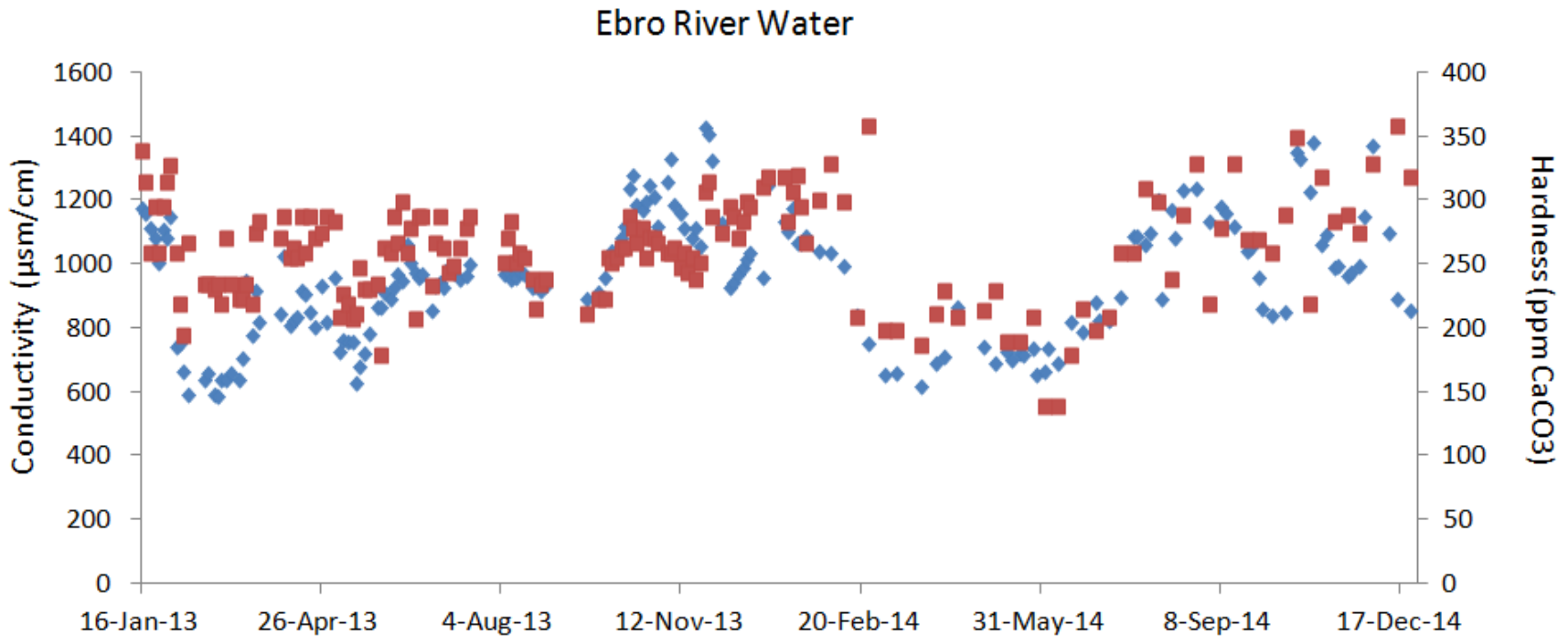
Wastewater Reuse Strategy

- 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 μ S/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

| Compound | Ebro River | RO Permeate |
|--|------------|-------------|
| Conductivity ($\mu\text{S}/\text{cm}$) | 950 | 19 |
| Cl (mg/L) | 95 | 2.9 |
| CaCO ₃ (mg/L) | 260 | < 0.1 |
| SO ₄ (mg/L) | 160 | 0.02 |
| NH ₃ (mg/L) | 0.1 | < 0.8 |
| PO ₄ (mg/L) | 0.1 | < 0.002 |
| TOC (mg/L) | 1.2 | < 0.3 |

■ 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

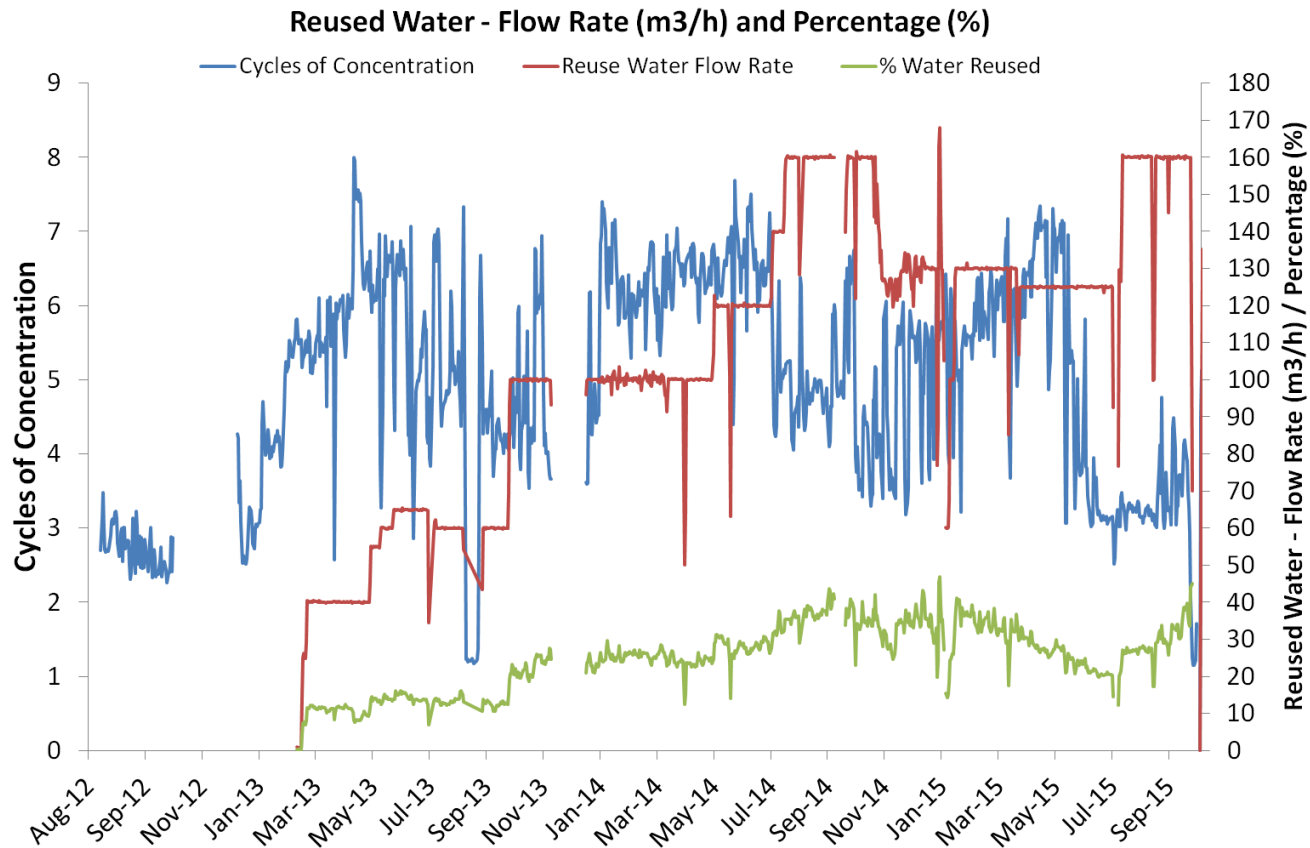
- Microbiological growth due to high nutrients and organic content
- Chloramine formation lowering biocide activity

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%)



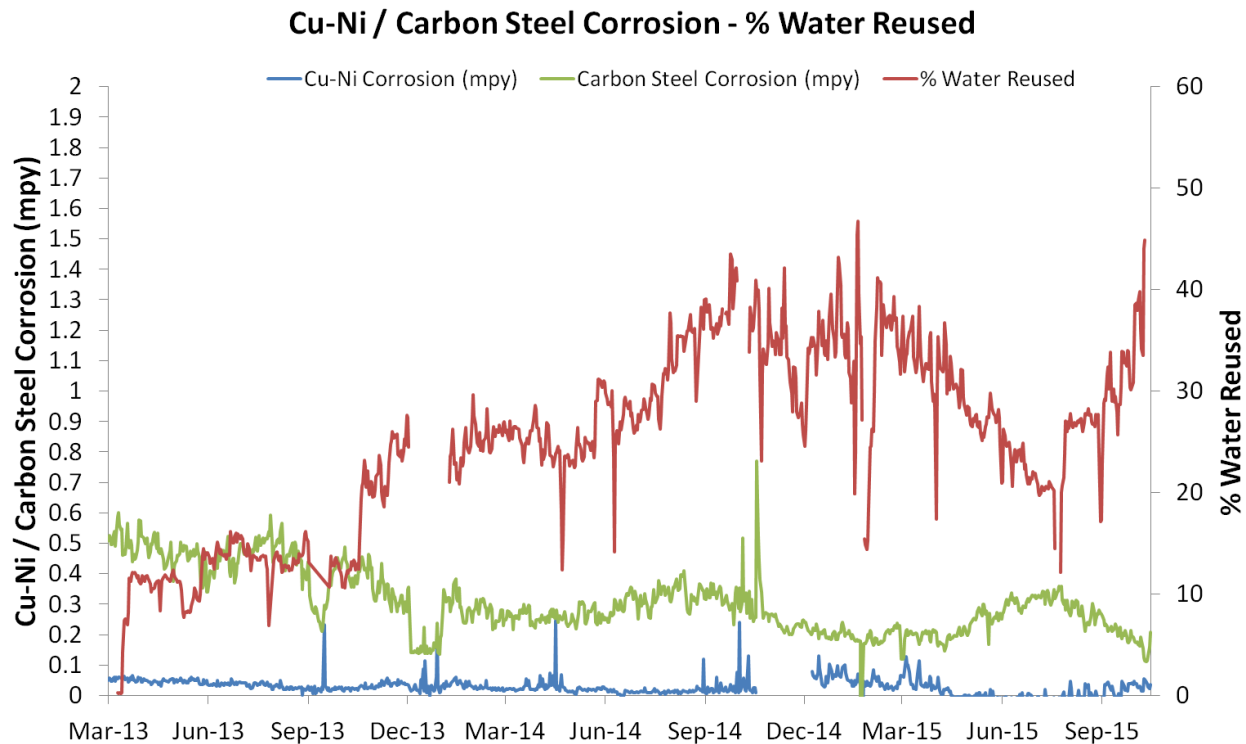
Cooling Towers Concentration Cycles

- 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%)

| Compound | Ebro | RO Permeate | Ebro x 4 | Permeate x 7 |
|--------------------------|------|-------------|----------|--------------|
| Conductivity (µS/cm) | 950 | 19 | 3,800 | 135 |
| Cl (mg/L) | 260 | 2.9 | 1,040 | 21 |
| CaCO ₃ (mg/L) | 95 | < 0.1 | 380 | < 1.0 |
| SO ₄ (mg/L) | 160 | 0.02 | 640 | 0.07 |
| NH ₃ (mg/L) | 0.1 | < 0.8 | 0.4 | < 5.0 |
| PO ₄ (mg/L) | 0.1 | < 0.002 | 0.4 | < 0.02 |
| TOC (mg/L) | 1.2 | < 0.3 | 4.8 | < 2.0 |

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

| | River Water (100%) | River Water (60%) + Reclaimed Water (40%) |
|---------------------------------|---------------------------|--|
| Cooling Water NH3 (mg/L) | 0.05 | 0.03 |
| Cooling Water TOC (mg/L) | 19.3 | 21.0 |

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 undergone a Reverse Osmosis filtration step present no health concerns when compared with conventional pre-treated river water



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**Thank
You**

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