Outcomes from WA1

Practical tools and guidelines for MAR operators.
Application in real MAR sites.

Final Project meeting
17th – 18th June, Dübendorf

C. Sprenger (KWB), M. Hernandez (CETaqua), O. Gibert (CETaqua), E. Vilanova (AMPHOS21), S. Hannappel (HYDOR), B. de la Loma González (KWR), J. Plattner (FHNW)

This project has received funding from the European Union’s Seventh Programme for Research, Technological Development and Demonstration under Grant Agreement no. 308339.
• Evaluation of fate of micropollutants: Removal matrix
• Column experiment with reclaimed water
• Real application of knowledge gathered:
  • MAR in Castellón
  • MAR in Sant Vicenç dels Horts
  • Bioassays
  • LCC / LCA
• Available material
• Conclusions
### Review of 46 Scientific Papers

#### MOST SIGNIFICANT FIELD CONDITIONS INFLUENCING MICROPOLLUTANTS REMOVAL:

- Residence time
- Redox conditions
  - Aerobic (Oxic)
  - Nitrate reduction
  - Fe – Mn reduction
  - Sulphate reduction

#### OTHER RELEVANT CONDITIONS

- Temperature
- Organic Carbon
- Initial concentration
- Type of aquifer

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### Legend

- **Removed (90-100% of removal)**
- **Significantly removed (50-90% of removal)**
- **Partially removed (20-50% of removal)**
- **Not removed (0-20% of removal)**
- **Partially removed or Not removed depending on the site**

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### Reduction conditions

<table>
<thead>
<tr>
<th></th>
<th>Oxic</th>
<th>NO3</th>
<th>Fe-Mn</th>
<th>SO4</th>
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<tr>
<td>&lt; 7 days</td>
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<td>&lt; 1 month</td>
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<td>&lt; 6 months</td>
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<tr>
<td>&gt; 1 year</td>
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</table>

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**Example Reduction Conditions**

- Carbamazepine
- Bezafrate
- Gemfibrozil
EXPERIMENTAL METHODOLOGY

DEMEAU site (2013):
- WWTP of El Prat del Llobregat
- Treatment capacity of 420,000 m³/day
- Population: 2,275,000
- Recharge water: Secondary Effluent
- Presence of emerging micropollutants: YES

ENSAT site (2011):
- MAR system in Sant Vicenç dels Horts
- Infiltration capacity: 1 Mm³/year
- Infiltration rate: 1 m³/m²/d (5600 m²)
- Recharge water: Raw Llobregat River water
- Presence of emerging micropollutants: YES

OBJECTIVE

- Improvement of removal rates of emerging micropollutants.
- Use low-cost technology using sub-products, recycled waste.
- Confirm at lab-scale trends observed at field scale.
EXPERIMENTAL METHODOLOGY

Demonstration of promising technologies to address emerging pollutants in water and waste water

Tested sand filters feed flows:
- 2.5 mL/min
- 5.0 mL/min

Aquifer material (sand + 1% O.M.)

Vegetal compost (additional O.M.)

Aquifer material (sand + 1% O.M.)

Aquifer material (sand + 1% O.M.)

REGULAR SAMPLING POINT

ADDITIONAL SAMPLING POINT

inflow
# RESULTS

## INF 1

<table>
<thead>
<tr>
<th>Compound</th>
<th>Mean [ng L⁻¹]</th>
<th>Min [ng L⁻¹]</th>
<th>Max [ng L⁻¹]</th>
<th>Std. dev. [ng L⁻¹]</th>
<th>QFa [%]</th>
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<tbody>
<tr>
<td>DICLOFENAC*</td>
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*a detection frequency above LOQ, n= 21 samples. (*) Spiked contaminant

## INF 2

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*a detection frequency above LOQ, n= 21 samples. (*) Spiked contaminant
Scientific publication:

Influence of a compost layer on the attenuation of 28 selected organic micropollutants under realistic soil aquifer treatment conditions: Insights from a large scale column experiment

Mario Schaffer a,*, Kerrin Franziska Kröger a, Karsten Nödler a, Carlos Ayora b, Jesús Carrera b, Marta Hernández c, Tobias Licha a

a Geoscience Center, Dept. Applied Geology, University of Göttingen, Goldschmidtstr. 3, 37077 Göttingen, Germany
b GHS Institute of Environmental Assessment and Water Research (IDAE-CSIC), Jordi Girona 18-26, 08034 Barcelona, Spain
c CETaqua, Water Technology Center, Carretera d’Esplugues 75, 08940 Cornellà de Llobregat, Barcelona, Spain
5. RESULTS

- 28 selected compounds results and analysis:

Table 3 – Attenuation behavior of the investigated compounds in the column systems.

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Retardation C1/C2</th>
<th>Degradation C1/C2</th>
<th>Influence of reactive layer</th>
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<td>AAA</td>
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<tr>
<td>Ata</td>
<td>+</td>
<td>0</td>
<td>(+)</td>
</tr>
</tbody>
</table>

Notes:
- 0...no retardation (R = 1.0)
- +...slight retardation (R > 1.0–1.5)
- ++...Moderate retardation (R > 1.5–2.5)
- +++...strong retardation (R ≥ 2.5)
- Ø...not detected in the outflow
- 0...no degradation
- +...low degradation (=10–50% of c0)
- ++...high degradation (>50% of c0)
- -...concentration increase (TP)
- (+) due to stronger retardation
- (-) formed transformation product
- Complete removal (C2)
Field experiences (Literature):

- Residence time < 7 days
- Reduction state: denitrification

Column experiments:
- Residence time < 7 days
- Reduction state: denitrification

Main conclusion: less removal in column experiment than in real sites (field conditions): optimistic expectations in field experiences!
FIELD WORK DONE

**MATURE MAR FACILITY: Den Haag, The Netherlands**
- Assessment of micropollutants fate using historical data

**MATURE MAR FACILITY: Sant Vicenç dels Horts (Barcelona, ES):**
- Leaching tests (organic layer)
- Bioassays (toxicity)
  (wet cond. – dry cond. – mixed cond.)

**MATURE MAR FACILITY: Tegel, Berlin (Germany):**
- Assessment of micropollutants fate using historical data

**MATURE MAR FACILITY: Den Haag, The Netherlands**
- Assessment of micropollutants fate using historical data

**NEW MAR IMPLEMENTATION: Vall d’Uixó (Castellón, ES):**
- Risk assessment reclaimed water
- Bioassays (toxicity)
- Micropollutants quantification (June 2014 – Jan 2015 – Apr 2015)
**WA4: Evaluating toxicity of MAR samples**

**MATURE MAR FACILITY:** Sant Vicenç dels Horts (Barcelona, ES):
- Bioassays (toxicity)

**NEW MAR IMPLEMENTATION:** Vall d’Uixó (Castellón, ES):
- Bioassays (toxicity)

**Quadruplicated samples:**
- Bulk chemistry (AB, IGME)
- Emerging compounds
  - (Gottingen, KWB Berlin, UJI Castellon)
- Toxicity BDS (Amsterdam)
- Toxicity EAWAG (Switzerland)

<table>
<thead>
<tr>
<th>Surface</th>
<th>Ground</th>
<th>WWTP</th>
<th>River</th>
<th>Ground</th>
<th>Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cytotoxicity</td>
<td>Estrogenic activity</td>
<td>Anti-androgenic activity</td>
<td>Anti-progesterone activity</td>
<td>Glucocorticoid activity</td>
<td>Genotoxicity</td>
</tr>
<tr>
<td>Genotoxicity</td>
<td>Genotoxicity + metabolic activation</td>
<td>Oxidative stress response</td>
<td>Lipid metabolism disturbances</td>
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</tr>
</tbody>
</table>

**Legend:**
- no activity
- weak activity
- strong activity
SYNERGIES WITH OTHER WAs

MATURE MAR FACILITY:
Den Haag, The Netherlands
- LCC/LCA

MATURE MAR FACILITY:
Sant Vicenç dels Horts (Barcelona, ES):
- LCC/LCA
- Workshop Drivers and Barriers in Barcelona: October 2015

WA5: Evaluating drivers and barriers
- DEMEAU project demonstrates that it is possible to enhance the removal of some micropollutants with organic matter addition. The incorporation of a reactive layer increases the elimination percentage of 16 of the 28 target emerging pollutants.

- **Residence time** is one of the key parameters to increase the percentage of elimination, according to the literature review carried out. Redox conditions can also influence in the percentage of elimination.

- Field test micropollutants’ elimination percentages are higher than in column experiments. Hence, some properties/processes occurring in soil-aquifer treatment cannot be simulated at column scale.

- **Collaboration** with other WAs has allow to open new research lines (Bioassays & toxicity) and to develop a new language to communicate with our stakeholders (participative sessions, LCA, LCC)

- DEMEAU project contributes to bring practical tools and guidelines to MAR operators and is a driver for MAR implementation in Europe.
MANY THANKS TO THE TECHNICAL TEAM FOR THEIR WORK AND....
THANK YOU FOR YOUR ATTENTION!!

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Thank you for your attention!

This project has received funding from the European Union’s Seventh Programme for Research, Technological Development and Demonstration under Grant Agreement no. 308339.